COLLABORATIVE NETWORKED ORGANIZATIONS

A research agenda for emerging business models

Edited by
Luis M. Camarinha-Matos
Hamideh Afsarmanesh

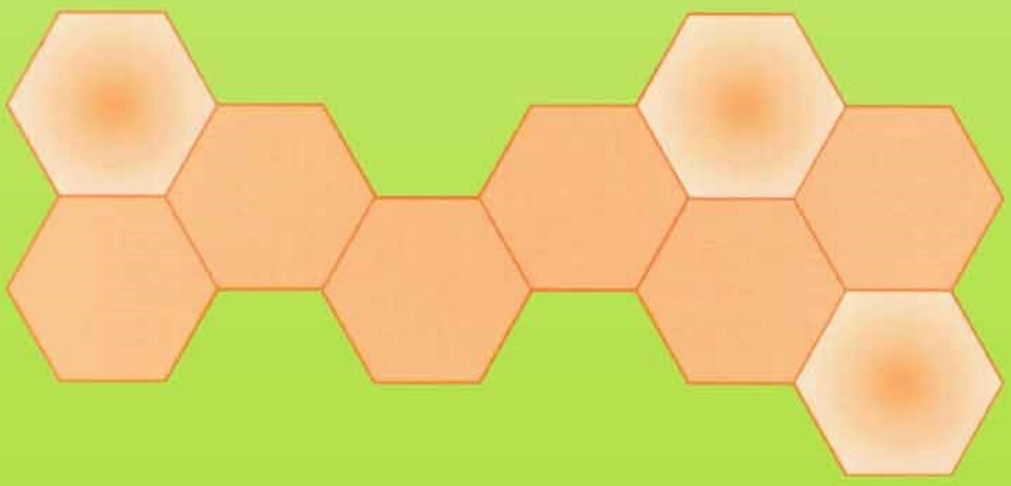

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TABLE OF CONTENTS

FOREWORD ..... *ix*
PREFACE ..... *xi*

1 INTRODUCTION 1
1.1 TOWARDS NEXT BUSINESS MODELS 3
1.2 SOME BASIC CONCEPTS 7

2 NEW COLLABORATIVE FORMS 11
2.1 OVERVIEW 13
2.2 VO IN INDUSTRY: STATE OF THE ART 15
Spiros Alexakis, Bernhard Kölmel, Tobias Heep
2.3 VIRTUAL ORGANISING SCENARIOS 27
Bernhard R. Katzy, Hermann Loeh, Chunyan Zhang
2.4 EMERGING COLLABORATIVE FORMS 41
Luis M. Camarinha-Matos, Eoin Banahan, Jorge Pinho de Sousa, Flavius Sturm, Hamideh Afsarmanesh, José Barata, Jim Playfoot, Volker Tschammer

3 GLOBAL AND REGIONAL RESEARCH AGENDAS 65
3.1 OVERVIEW 67
3.2 TARGETING MAJOR NEW TRENDS 69
Luis M. Camarinha-Matos, Hamideh Afsarmanesh. António Abreu
3.3 CHALLENGES OF COLLABORATIVE NETWORKS IN EUROPE 77
Hamideh Afsarmanesh, Vladimír Mařík, Luis M. Camarinha-Matos
3.4 A CHALLENGE TOWARDS VO IN JAPANESE INDUSTRY: INDUSTRIAL CLUSTER 91
Toshiya Kaihara
3.5 COLLABORATIVE NETWORKS IN AUSTRALIA – CHALLENGES AND RECOMMENDATIONS 97
Laszlo Nemes, John Mo
3.6 A BRAZILIAN OBSERVATORY ON GLOBAL AND COLLABORATIVE NETWORKED ORGANIZATIONS 103
Ricardo J. Rabelo, Alexandra A. Pereira-Klen
3.7 SOME AMERICAN RESEARCH CONCERNS ON VO 113
H T Goranson

4 HUMAN, SOCIETAL, AND ORGANIZATIONAL ASPECTS 119
4.1 OVERVIEW 121
4.2 SOCIO-ORGANIZATIONAL CHALLENGES IN THE CREATIVE ECONOMY 123
Eoin Banahan, James Playfoot
4.3 TOWARDS STRATEGIC MANAGEMENT IN COLLABORATIVE NETWORK STRUCTURES 131
Flavius Sturm, Jeroen Kemp, Ruben van Wendel de Joode

4.4 COLLABORATIVE KNOWLEDGE NETWORKS 139
Stephen Evans, Norman Roth
4.5 PERFORMANCE MEASUREMENT AND ADDED VALUE OF NETWORKS 147
Stephen Evans, Norman Roth, Flavius Sturm
4.6 ETHICAL AND MORAL ISSUES FACING THE VIRTUAL ORGANIZATION 153
Scott Hawkins

5 INFORMATION AND COMMUNICATION TECHNOLOGY FACTORS 171
5.1 OVERVIEW 173
5.2 SUPPORT INFRASTRUCTURES FOR NEW COLLABORATIVE FORMS 175
Luis M. Camarinha-Matos, Hamideh Afsarmanesh
5.3 AGENT TECHNOLOGY 193
Vladimír Mařík, Michal Pěchouček
5.4 ON EMERGING TECHNOLOGIES FOR VO 207
Luis M. Camarinha-Matos, Volker Tschammer, Hamideh Afsarmanesh

6 FOUNDATIONS AND MODELING 225
6.1 OVERVIEW 227
6.2 EMERGING BEHAVIOR IN COMPLEX COLLABORATIVE NETWORKS 229
Luis M. Camarinha-Matos, Hamideh Afsarmanesh
6.3 FORMAL MODELING METHODS FOR COLLABORATIVE NETWORKS 237
Luis M. Camarinha-Matos, Hamideh Afsarmanesh
6.4 AGENT TECHNOLOGY FOR VIRTUAL ORGANIZATIONS 245
Vladimír Mařík, Michal Pěchouček
6.5 MODELING SOCIAL ASPECTS OF COLLABORATIVE NETWORKS 253
António Lucas Soares, Jorge Pinho de Sousa
6.6 THE ORGANIZATIONAL SEMIOTICS NORMATIVE PARADIGM 261
Joaquim Filipe

7 AN EXAMPLE ROADMAP 273
7.1 A ROADMAPPING METHODOLOGY FOR STRATEGIC RESEARCH ON VO 275
Luis M. Camarinha-Matos, Hamideh Afsarmanesh
7.2 A STRATEGIC ROADMAP FOR ADVANCED VIRTUAL ORGANIZATIONS 289
Luis M. Camarinha-Matos, Hamideh Afsarmanesh, Hermann Löh, Flavius Sturm, Martin Ollus

ANNEXES 313
A.1 AUTHORS AND CONTRIBUTORS 315
A.2 METHOD OF WORK IN THINKcreative PROJECT 327

SUBJECT INDEX 333
AUTHOR INDEX 335

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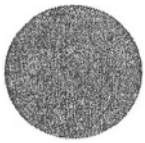


FOREWORD

A research agenda for collaborative networks

Purpose. Many practical application experiments and pilot cases nowadays provide evidence on what works and what still remains as a challenge for collaborative networked organizations (CNOs). The fast evolution of the information and communication technologies and in particular the so-called Internet technologies, also represents an important motivator for the emergence of new forms of collaboration. However, most efforts in this area are highly fragmented, considering only some partial facets and not a holistic perspective that would be required. We are therefore at a point in which it is necessary to define much more consolidated and sustainable research strategies for a second phase of research and development in this area.

This book addresses the main disciplines involved in CNOs. It further synthesizes the views and opinions expressed by a large number of visionaries from the main disciplines involved in CNOs, and offers a comprehensive set of recommendations for the establishment of a research agenda on collaborative networks. As recognized experts in their specific areas, different authors in this book have presented work that is backed by a large number of research results, each focusing on specific facets of collaborative networks, and coming out of a large number of international and national projects.

Intended audience. Given the objectives of the book, the intended audience includes mainly the research strategy planners, decision-makers at the research funding organizations, group leaders in research institutions, and the heads of research departments in companies interested in research and innovative development activities in the area of e-business and collaborative networks. Furthermore, the book can also provide valuable directions to PhD advisors and PhD students, who try to focus their research themes.

Style. This is a multi-author book and therefore, although an attempt is made by the editors to achieve minimal uniformity, the reader should expect to find different styles of writing along the various chapters.

In order to facilitate the reading of the book however, the editors have also provided six summary overviews, one at the beginning of each of the main parts of the book. These overviews offer a guide to the corresponding chapters included in each part, as well as a summary of the main messages conveyed by those chapters.

Nevertheless, the reader needs to be aware of the fact that the CNO paradigm is a highly multi-disciplinary area for research, and requiring contributions from a large number of experts from different research communities. This by itself introduces a new level of heterogeneity in the styles, as different communities have different ways of expressions, different literary styles, and in each discipline different inherent semantics are associated to the terminology used.

Sources. This book includes both the integrated summaries of the main findings and the recommendations resulted from various initiatives promoted by THINKcreative project, namely several regional and focused workshops, the Delphi survey, and

discussion panels, as well as some individual contributions in form of position papers. The above activities, funded in part by the European Commission under the IST programme, were carried out during a period of about two and half years, and involved more than 250 industry and academic experts, mostly from Europe. In addition to the THINKcreative-based contributions, a number of other researchers from other geographical regions (Australia, Japan, Brazil, and USA) were invited to also contribute with their perspectives on the main research challenges in this area. Finally a roadmap is also presented in this book, aimed at the strategic research on advanced virtual organizations. This roadmap was also developed in the context of another IST project, the VOmap. The VOmap took many of the THINKcreative findings and recommendations as input towards generating its research roadmap. The roadmap resulted in the VOmap project is included in the book as an example of a possible research program for the CNO area.

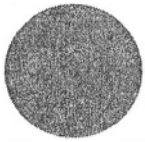
Book structure. In summary, the book sections include the following:
Section 1 presents the general motivation and introduces a brief intuitive definition of the main concepts used along the text. Section 2 summarizes the characteristics of existing and emerging collaborative network forms and draws some scenarios regarding future collaboration forms. Section 3 is devoted to the identification of general requirements in CNOs research and development, including the perspectives from different geographical regions. Section 4 is focused on the discussion of challenges from a socio-economic and managerial perspective, where the value systems, ethical, and moral issues are also addressed. Section 5 addresses the technological support in terms of current trends, emerging technologies, standards, and needs. Section 6 addresses the issue of establishing a formal theoretical foundation for CNOs and what are the most promising approaches to consider as the baseline. Finally, Section 7 includes a concrete example of a strategic research roadmap generated by the IST VOmap project. Additionally, two Annexes are provided, including the biographic information on the authors, and a summary of the working methodology adopted in THINKcreative project.

Please note that although a large number of topics are presented and discussed in the book, clearly enough not all aspects of the CNO paradigm are covered. Therefore, in addition to what is included in the book, some other aspects of collaborative networks require further research, e.g. the topic of knowledge management, a horizontal issue crossing different areas of CNO, is not much emphasized. Nevertheless, the included topics address the strong needs for a comprehensive research effort inthis area.

The editors would like to thank the large community of experts involved in this work for their many valuable opinions, suggestions, and recommendations. On behalf of the THINKcreative consortium we also thank the European Commission, the Commission's project officer Joel Bacquet, and the review team, Professors José Manuel Mendonça and Ulrich Berger for their support.

We hope the result of this work can constitute a valuable input for those concerned with the definition of research directions towards a new generation of collaborative networked organizations.

The editors
Luis M. Camarinha-Matos, *New University of Lisbon, Portugal*
Hamideh Afsarmanesh, *University of Amsterdam, The Netherlands*



PREFACE

Improving competitiveness of European industry is one of the major goals set up by the European Union Member States at the Lisbon Summit. In this respect Information and Communication technologies (ICT) play an important role to foster innovative products and business processes.

What is at stake is the productive use of ICT. In the case of e-Business it is not limited to Internet connections or selling on-line. Competitiveness of organisations needs to be raised and this can be achieved by increasing their productivity through fully exploiting the potential of ICT. The full potential has not been achieved yet. The challenge has now shifted to incorporate e-Business in both the internal and external activities of organisations. Full benefits for organisations of all sizes will come from their participation in the evolution of clusters from informal alliances of business partners into collaborative networked organisations. These innovative, emerging collaborative forms, also called "Virtual Organisations", are characterised by on-demand co-operation, requiring highly inter-linked infrastructures and business models.

Initial research and development at both European and national levels, has been carried out in this domain, resulting in infrastructures, methods, and prototypes which in many cases were not generic enough to be fully propagated in the whole industry. Today there is an essential need to conduct fundamental research to better understand these emerging forms of collaboration.

This book is one of the main results of an EU IST-2000-29478 project, THINKcreative (Thinking network of experts on emerging smart organisations), which is a working group identifying the organisational forms, infrastructures, modelling tools, and socio-organisational needs for the next 5, 10 and 15 years. It provides a research agenda in this field by combining contributions from different disciplines, like complexity theory, biology, artificial intelligence, game theory, etc.

I hope that the reader will be stimulated by these challenges, and that he could possibly contribute to the foundations of this collaborative network science applied to organisations.

Joël Bacquet,
(Head of sector "Virtual Organisations")
Directorate General Information Society
European Commission.

INTRODUCTION

1.1 TOWARDS NEXT BUSINESS MODELS

This book summarizes the main findings of the THINKcreative project towards the establishment of a research agenda for emerging collaborative networks. This project was launched as a European advisory group in the area of collaborative networked organizations with the mission to identify and characterize the emerging collaborative organizational forms, the required infrastructures, modelling and application tools, and the socio-organizational needs for the next 5, 10, and 15 years.

The emerging paradigm of collaborative networked organizations (CNOs), or simply collaborative networks, fundamentally changes the way that commercial, industrial, cultural, and social activities are organized. In addition to the rapid evolution of traditional supply chain and outsourcing practices, a growing trend nowadays consists of tasks performed by autonomous teams of a small number of people or small and medium enterprises (SMEs), set up as independent contractors or small firms and linked by a network. These teams usually come together, some times in temporary arrangements, to tackle various projects, and may dissolve once the work is done. Consider, for instance, the wide variety of recent radical outsourcing in design for manufacturing, in software development, or in the film industry: in almost every case, in one way or another "Smart Organizations", "Virtual Organizations" or "Networked Organizations" represent the collaboration configuration. This trend is also observed in many other sectors.

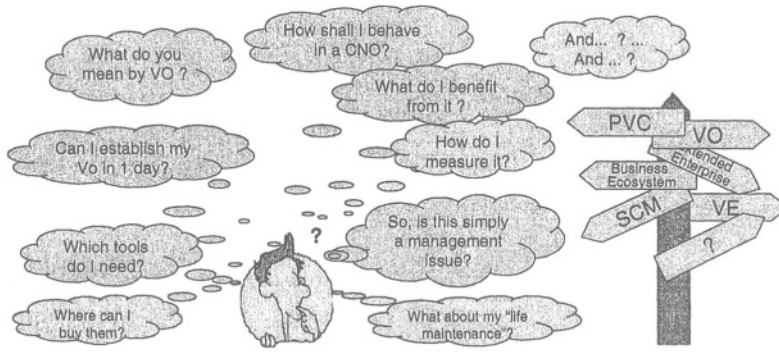

What do you mean by VO ?
How shall I behave in a CNO?
And... ? ... And ... ?
What do I benefit from it ?
Can I establish my Vo in 1 day?
How do I measure it?
PVC
VO
Extended Enterprise
Business Ecosystem
SCM
VE
?
So, is this simply a management issue?
Which tools do I need?
Where can I buy them?
What about my "life maintenance"?

Figure 1 – Going "net-collaborative"

It is frequently stated that collaborative networks provide a basis for competitiveness, world-excellence, and agility in turbulent market conditions. These networks can support SMEs to identify and exploit new business potentials, to boost innovation, and to increase their knowledge. The networking of SMEs with large-scale enterprises also contributes to the success of both kinds of companies in the global market. Nevertheless the practical implantation of this paradigm is still far from the initial expectations.

Most often Information and Communication Technologies (ICT) are seen as an important enabler for CNOs. However, in order to launch and efficiently operate CNOs, there is a requirement of preparedness in terms of the organizations, the environment where they operate, and the involved individuals.

Long standing relationships - regional clustering being an example – can be formed as a base network, once their base requirements are fulfilled. Such a network, when driven by the willingness to cooperate and anchored on: common business practices, supporting *institutions*, and common infrastructures and ontologies, form a business ecosystem, in which trust is incrementally built and out of which dynamic virtual organizations can be created whenever business opportunities arise. The need for such long-term sustainable networks is now widely recognized as the basis or breeding environment that can support the realistic emergence of true dynamic virtual organizations (VOs). At the same time, the temporary nature of VOs, its needed inter-organizational processes, and the potentially diverging objectives of the partners, require the development of a VO management system, on top of and based on the organization preparedness created in the VO breeding environment (VBE). The VBE is also the boosting element for emergence of new human support *institutions* and mechanisms for "life maintenance" in a turbulent business environment that may seem somewhat contradictory to the profit making bias for businesses. As such, the sustainability must build on both the new approaches to cope with the individual calls for stability and the agility required by business needs.

The human collaborative relationships, namely based on common professional interests, approaches, and motivations, lead to another form of CNOs, namely, the professional virtual community (PVC). Going beyond the traditional virtual communities that have populated the web during the last years, PVCs have distinctive elements and are mobilized to face specific challenges. Their distinctive facets are not only due to their professional needs (e.g. infrastructures, tools, protocols). Further, they cannot be dissociated from the underlying business ecosystem of the society, due to their contractual links (social-bounds), with all the consequences to the intellectual property and life maintenance levels. Nevertheless, PVCs are one of the most relevant elements for keeping the business ecosystem "alive" and for launching and operating dynamic VOs of the future.

Thus any core research initiative on collaborative networked organizations must holistically address these three main inter-related areas: VO Breeding Environments (VBE), management of Virtual Organizations (VO), and Professional Virtual Communities (PVC). Furthermore, there is a growing awareness that the CNO developments should be based on contributions of multidisciplinary nature, not only from the Information and Communication Technologies, but also from the socio-economic, cognitive science, operations research, organizational and business

management, legal, social security, and ethical areas. Confirming this need some trends can be identified:

- New behavioral forms, which include new ways of work and even new moral and ethical attitudes,
- New cooperation agreements and social contracts,
- New liability agreements and risk negotiation practices,
- New ways of generating value for common developments,
- Correspondingly, handling new challenges on IPR and ownership identification, and
- Definition of a legal framework, affecting VOs and CNOs in general.

Furthermore there is a need for mechanisms to empower human relationships as a way to induce creativity, to strengthen cohesion and sustainability and to reach responsiveness to market turbulence. However current developments in the area are only touching the surface of the collaborative processes, still **mostly technology-driven** and achieved independent of each other and at different R&D projects; thus repeatedly provide only a very primitive *interaction infrastructure* among the organizations involved in the CNO. Nevertheless, the involvement of different communities of experts in any CNO research initiative is a rather difficult process that requires proper planning and clear identification of the actors and their potential roles.

In the European context, the continued dedicated efforts on virtual organizations (e.g. through Esprit, 1ST, and IMS research programmes), although fragmented, has already led to the formation of a critical mass and a culture of collaboration, giving early and systematic entry into the area. This "movement" is consistent with the process of European integration, which represents a push towards a "collaboration culture", while preserving the desire to leverage the regional values and assets.

In order to support this "movement", the THINK*creative* initiative was launched aiming at establishing a working group to act as a European advisory group in the area of smart and emerging organizations in the framework of the "knowledge and skills economy". The general goal was to identify and characterize the emerging collaborative organizational forms, the required infrastructures, modelling and application tools, and the socio-organizational needs for the next 5, 10, and 15 years. As specific goals this initiative included:

- Characterization of the evolving and highly unpredictable business ecosystems;
- Identification of required tools;
- Understanding of cooperation forms, and suitable agreement models;
- Clarification of the new relationships between humans and organizations (stationary workers, teleworkers, e-lancers);
- Definition of new value systems and performance measures for intangible assets;
- Identification of necessary inter-linking between "global production" and the "local customization";
- Identification of training requirements and social needs.

THINK*creative* is a network of experts from Academia and Industry in different regions of Europe, who have complementary expertise in the areas such as: smart and virtual organizations, virtual enterprises, virtual communities, collaboration

support systems, interoperation, knowledge and information management, business process modeling, social and ethical issues, and electronic business. These experts however are related to two distinct communities that so far have not had much close interaction and co-working, namely:

- The Information and Communication Technologies / Computer Science community; and
- The Socio-organizational / Management community,

Putting experts from these two communities together – a challenge in itself – represented a very fruitful context, but also a pre-requisite to deal with the multi-disciplinary challenges of advanced and emerging collaborative networked organizations.

This book summarizes the main findings of the THINK*creative* project towards the establishment of a **research agenda for emerging collaborative networks.**

A fundamental pre-requisite when designing a research strategy on CNOs for the next 5, 10, to 15 years is the identification of the future trends and goals towards which the area is developing. Therefore, although not trivial, a **vision** must be defined, as a moving target, based on views and input from both industry and research. The approach towards identification of visions for future of CNO must carefully consider and analyze the relationships and impacts among all parameters in the CNO environment (e.g. ICT, social/organizational factors) and a continuous interaction between the technological/social trends and the business needs. Therefore, first the characterization of **trends** and plausible **scenarios** as well as the identification of **future ICT and non-ICT needs,** including socio-organizational models, management and coordination methods, interoperability infrastructures, business functionalities, etc. are required. And only then, an approach to reach such a vision can be defined.

To reach the vision however, developments need to apply today's state-of-the-art as the baseline. This is, in itself, a major challenge for the research community – on one hand how to generate sustainable breakthroughs without being trapped by the short time life cycles of most ICT "waves", and at the same time being able to generate solutions that can be validated by real-world applications.

SOME BASIC CONCEPTS

What is a collaborative networked organization?
What is a virtual enterprise?
And a virtual organization?
Is this a new paradigm?
These are some of the questions very often asked and for which it is hard to find precise answers. In order to facilitate the reading of this book by those less familiar with this area, this section introduces some "informal" definitions of the main concepts used in this book.

Several new organizational paradigms have emerged in recent years, such as virtual manufacturing, lean enterprise, agile manufacturing, and holonic systems; namely in the context of the industrial organizations and as a response to new challenges of globalization. Similarly, the need to remain competitive in the open market has forced companies to seek "world-class" status and therefore, to concentrate on their core competencies while looking for alliances when additional skills / resources are needed to fulfill business opportunities. Introduction of these concepts required enterprises to face successive "waves of restructuring" during the last decades. Emergence of the virtual enterprise (VE) concept [4] also appears in the natural sequence of these restructuring processes, enabled by the fast developments in the information and communication technologies (ICT).

Some authors see the roots of the VE concept in early works of economists like Oliver Williamson in the 1970s. Along his vast work, and in particular in the "Markets and Hierarchies" [9] Williamson established the study of Transaction Cost Economics as one of the first and most influential attempts to develop an economic theory of organizations. He defends that manufacturing firms should make much greater use of externally purchased goods and services, rather than internally supplied ones. Through identifying the important variables that determine the transaction costs, the work of Williamson contributed to the better understanding of business interactions among enterprises.

These ideas had a more evident impact with the booming of the "outsourcing" wave in the 1980s. Outsourcing became very attractive when managers had to reduce the organization overheads and eliminate their internal inefficient services, towards the so-called lean manufacturing, as it transfers these problems to the outside of the organization, namely the efficient service providers. For many enterprises, outsourcing some services allows them to concentrate on their core competencies. For others, outside contractors simply provide complementary services for which the company lacks adequate internal resources or skills. In parallel with the outsourcing tendency, another transformation can be observed in the last years in large companies. This second transformation is towards companies' reorganization in terms of their product lines, leading to some "federation" of relatively autonomous departments.

The above mentioned transformations, putting the emphasis on networking and partnership / collaboration, have raised a large interest for some new disciplines such as the coordination theory, organizational theory, and sociology of the industrial organizations.

Nevertheless there is not yet a commonly agreed definition of the virtual enterprise concept. This is partially due to the fact that there are many differences of opinion among various communities working on this topic, mostly depending on whether they come from the ICT or the Management discipline. For instance, some experts from sociology and management conceive virtual enterprises without the need for specific ICT-based support environment, while for ICT experts such an infrastructure is the key element that can realize this concept.

Therefore a large number of definitions appear in the literature. For instance, in the NIIIP project (a USA funded research and development initiative): "a Virtual Enterprise is a temporary consortium or alliance of companies formed to share costs and skills and exploit fast-changing market opportunities" [7]. Byrne et al. in [1] specify that a "Virtual Corporation is a temporary network of independent companies - suppliers, customers, even rivals - linked by information technology to share skills, costs and access to one another's markets. It will have neither central office nor organization chart. It will have no hierarchy, no vertical integration". For Walton and Whicker "the Virtual Enterprise consists of a series of co-operating 'nodes' of core competence which form into a supply chain in order to address a specific opportunity in the market place" [8]. Trying to combine various elements of these and other definitions, the ESPRIT IV PRODNET project suggested the following definition [2]:

"A ***virtual enterprise*** is a temporary alliance of enterprises that come together to share skills or core competencies and resources in order to better respond to business opportunities, and whose cooperation is supported by computer networks."

Two key underlying elements in this definition are the *networking* and the *collaboration.* Clearly, there is a tendency to describe a virtual enterprise as a network of collaborating enterprises. Therefore, under this paradigm, a number of pre-existing enterprises or organizations with some common goals come together, forming an interoperable network that acts as a single organization. In other words, virtual enterprises materialize through the selection of skills and assets from different firms and their synthesis into a single business entity.

In fact, the establishment of cooperation agreements between enterprises is not a new phenomenon, rather belonging to the very nature of the business world. But the use of communication and information technologies to support agile cooperation, as one key characteristic of the virtual enterprise concept, brings this approach to a new level of effectiveness. Cooperation on a global scale (intercontinental) is expected to substantially increase, as distance will no longer be a major limiting issue.

The wide variety of different networked organizations and the emergence of new production management / service provision paradigms have led to the generation of a number of related terms such as the extended enterprise, virtual organization, breeding environment, and professional virtual communities. Some authors even use some of these terms as synonyms to virtual enterprises although there are differences between their detailed meanings.

A brief intuitive description of the main concepts addressed in this area and appeared in different chapters of the book is represented below to provide some insight for readers into these paradigms.

Extended Enterprise. The concept of extended enterprise is typically applied to an organization in which a dominant enterprise "extends" its boundaries to all or some of its suppliers. In comparison, the VE can be seen as a more general concept including other types of organizations, namely a more democratic structure in which the cooperation is peer to peer. In this sense, an extended enterprise can be seen as a particular case of virtual enterprises.

Virtual Organization (VO). This is a concept similar to a virtual enterprise, comprising a set of (legally) independent organizations that share resources and skills to achieve its mission / goal, but not only limited to an alliance of for profit enterprises. Similar to the case of a virtual enterprise, these organizations provide to the outside world a set of services and functionality, as if they together represent a single organization. An example of the virtual organizations could be a virtual municipality, associating, via a computer network, all the organizations of a municipality (e.g. city hall, municipal water distribution services, internal revenue services, public leisure facilities, cadastre services, etc.). A virtual enterprise is therefore, a particular case of virtual organization [2], [6].

Dynamic Virtual Organization. This kind of VOs touches the issue of duration of VO's life cycle. Dynamic VOs typically refer to a VO that is established in a short time to respond to a competitive market opportunity, and has a short life cycle, dissolving when the short-term purpose of the VO is accomplished.

VO Breeding environment (VBE) represents an association or pool of organizations and their related supporting institutions that have both the potential and the will to cooperate with each other through the establishment of a “base” long-term cooperation agreement. When a business opportunity is identified by one member (acting as a broker), a subset of these organizations can be selected and thus forming a VE/VO. A breeding environment, being a long-term networked structure, presents the adequate base environment for the establishment of cooperation agreements, common infrastructures, common ontologies, and mutual trust, which are the necessary facilitating elements when building a new VE/VO [3]. In other words, VBE represents a group of organizational entities that have developed a *preparedness* for cooperation, in case a specific opportunity arises. Therefore such form of organization, also known as a source network, is considered by many authors as a pre-condition for the effective establishment of dynamic virtual organizations. Industry ***clusters*** or industry districts are examples of such breeding environments. The more frequent situation is the case in which the cluster is formed by organizations located in a common region, although geography is not a major facet when cooperation is supported by the computer networks.

Professional virtual community (PVC) is a term that represents the combination of concepts of virtual community and professional community. Virtual communities are defined as social systems of networks of individuals, who use computer technologies to mediate their relationships. Professional communities provide environments for professionals to share the body of knowledge of their professions such as similar working cultures, problem perceptions, problem-solving techniques,

professional values, and behavior [5]. When professional communities adopt computer networks and most of the practices and tools of virtual communities, they become professional virtual communities.

A well-known example of PVC is found in the area of concurrent engineering when teams of engineering professionals, eventually belonging to different organizations and located in different geographical places, collaborate in joint project development such as the co-design of a new product.

In recent research work the focus is more and more being directed to understanding the characteristics and needs of human-based collaborative networks. A particularly challenging issue is the interaction among the concepts of PVC, VBE, and VO. PVCs that can emerge in the context of a VBE, as well as supporting *institutions,* for instance for life-maintenance, are important boosting forces for launching and operating collaborative processes. These communities, spontaneously created or induced by the work relationships, are bound to certain social rules resulting from the (contractual) commitment (social bounds) of their members to the underlying organizations. An example of a context where these two concepts are clearly present is the new field of e-Science and Virtual Laboratories in which different scientists, belonging to different research centers and/or enterprises, can collaborate in the realization of joint remote scientific experiments.

All the cases mentioned above represent different forms of collaboration among groups of autonomous entities structured as networks. Therefore the term ***Collaborative Networked Organization*** (CNO) is also used in this book to represent all these and other emerging collaborative forms with similar properties.

Please note that the above definitions are just an attempt to give some (intuitive) background information to the readers less familiarized with the area. Therefore this section is neither intended to offer rigorous definitions of the involved concepts nor a description agreed by all communities coming from different disciplines, which are required to address different challenges in this area.

In fact one of the main findings and recommendations of the THINKcreative project points to the urgent need to invest time and effort into creating a sound theoretical foundation, where appropriate definitions shall be established for the general area of collaborative networked organizations.

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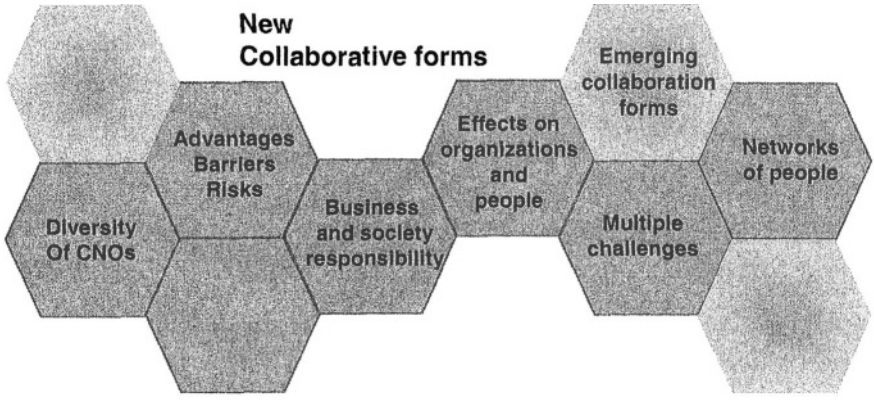
NEW COLLABORATIVE FORMS

2.1 OVERVIEW

The chapters included in this part are intended to provide a set of examples of collaborative networked organizations, serving both the purpose of giving a brief account of the state of implantation of the VE/VO paradigm in practice, as well as a reference for emerging forms of collaboration. The first chapter illustrates current industrial practices, highlighting the potentials and challenges of the implantation of the paradigm in the industrial world. Based on an analysis of the current trends, the second chapter introduces scenarios representing plausible futures for virtual organizing. Finally a collection of examples of emerging collaborative organizations is presented in the third chapter, focusing on the collaboration facets and pointing out the key research challenges motivated by each example.

In other words, this part of the book starts with an account of "where we are", proceeds to a description of "where we might or wish to go", and finally introduces a set of "signs of the current trends". The provided examples offer a reference framework that gives the reader a first motivation regarding the importance of the area and challenges ahead.



Some key messages conveyed in this part include:

- Collaborative networks offer a number of potential advantages, but their effective implantation faces many barriers and risks.
- Different types of collaborative networks already exist in a wide variety of application domains, and further are in the process of emerging. Each one of them exploits a certain set of potentials offered by virtual organizing. The wide diversity of application domains also shows that CNOs do not belong to a particular domain but rather represent an emergent scientific discipline.
- The sheer possibility of collaborating through the use of today's existing or emerging technologies has already created a wide range of collaborative network forms, most of them having non-profit objectives.
- Fostering collaboration is a managerial task that requires significant efforts, not only in business settings, but also at the society level.
- New collaboration practices have significant effects on both the organizations and individuals, in terms of ways of working and even ways of living. This in turn leads to new interactions and coordination mechanisms. In fact, from an initial focus on inter-organization collaboration, the emphasis is more and more put on the inter-personal collaboration and on the interactions between networks of organizations and networks of people.
- Future collaborative networks clearly raise a large number of challenges in terms of modeling, infrastructures, support tools, and new organizational and legal frameworks, what requires a multi-disciplinary approach.

VO IN INDUSTRY: STATE OF THE ART

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This chapter gives a short overview of Best Practice on the area of virtual organizations based on the example of four working industrial companies who have managed the transformation into a collaborative network approach to doing business. As a second step we identify promising business fields, which are supposed to profit from similar transformation. As a third and final step we try to identify drivers and barriers for the adoption of the virtual organization concept.

1. INTRODUCTION

This chapter provides a brief overview on introduction of virtual organization concept in industry. After an observation of four prototypical examples of virtual collaborative networks, we will generalize the findings and conclude on the type of companies and branches, which would potentially profit from the transformation into a virtual organization.

The final section concentrates on the drivers and inhibitors for the adoption of the virtual organization concept. Advantages VO's are identified and it is explained how far they can have a high impact on a company's success. On the other hand, the risks and challenges of a transformation into a virtual organization are mentioned while trying to explain how far those can have a negative effect on adoption of the virtual organization concept.

The described experiences have been collected during the VO related R&D projects VENTO (supported by CEC, Esprit), VORREITER (supported by the German ministry of Economics) and INFRANET (supported by CEC, IST).

2. DESCRIPTION OF BEST PRACTICE ON THE AREA OF VIRTUAL ORGANIZATIONS

The socio-economical, political and technological developments of the last two decades have drastically changed the way business is conducted at national as well

as international level. The distance factor has been eliminated while custom restrictions and market protectionism have seized to exist.

In the globalised and integrated market, conservative business schemes cannot guarantee economical viability any more. Business tend to adopt new practices of enhanced collaboration: successful industries move away major parts of their production to independent suppliers or sister companies best suitable for such tasks. At the same time subcontracting in major projects has gained a lot of support and is becoming a common practice.

Though the 'academically correct' virtual enterprise is far from being widely accepted, we have identified some successful best practices that are described in the following.

2.1 "Virtuelle Fabrik" EUREGIO Bodensee

The "Virtuelle-Fabrik Euregio Bodensee" (Virtuelle Fabrik means "virtual factory") is an example of a time-constrained network for single orders. The company pool consists of 40 different SMEs in four different European regions and has its origin in the Bodensee region in Switzerland and Germany. The core competencies of the "Virtuelle Fabrik" cover a wide area of the technologies used in manufacturing industries, whilst the focus is on the business segment of machine building.

Each partner can perform the acquisition of new orders, as they are completely independent in legal terms. Each order entails the establishment of a new cooperation process, in which not necessarily all members of the pool have to be involved. The "Virtuelle Fabrik" co-operates with so-called Brokers who are responsible for acquisitions.

Most orders comprise development and production of a prototype of a new developed product. Because the "Virtuelle Fabrik" is able to offer most of the common technologies and know-how in the manufacturing industries, they only have a few constraints regarding what they can produce.

Collaboration in a convenient way is also possible, but it is very labour intensive. A company, which wants to offer the same scope of products, needs to have a lot of specialists and production capacity.

The big advantages of the "Virtuelle Fabrik" are a broader scope of products, the participation in more orders, high flexibility and the speed in finding the right production partner. A risk or problem is the necessity of intensive communication between the partners. The interaction and communication between the partners succeeds by using a project management tool called "Webcorp". This tool, although limited, contains several useful features for complex project management.

2.2 Projektwerk.de

Projektwerk.de, founded in 1999 by Dr. Uta Blankenfeld and Dr. Christiane Strasse in Hamburg/Germany, is a virtual organization that consists of about 4500 Freelancers and small enterprises (figures from 2001). The core competencies of this VO are in the area of information technologies.

Projektwerk is an Internet-based platform that empowers freelancers and small enterprises to publish their profile, submit bid invitations, and search for cooperation. Thus, the Projektwerk-Database can be seen as a very lose network of experts. The communication between the members takes place exclusively over the common portal. The success of this concept can be seen in the number of approximately 1000 projects Projektwerk was involved in. The new cooperation obtains professional support in creating the organizational structure and administrating it by Projektwerk. Moreover, they offer mechanisms for searching appropriate partners and for doing the administration of the network in the newly founded cooperation. The basic registration for this platform is free. For 5 € per month one can obtain extended storage for e.g. photos, detailed profile.

The full benefits of Projektwerk can be seen in the cost effective option for doing bid invitations, flexibility, a huge variety of partners and competencies, and 24/7 access to the platform. Difficulties result from little trust in new partners as well as from regional differences.

2.3 Infranet Partners

Infranet partners consist of nine companies across the world. The current partners are: Fatman Oy (Finland), LK Netlon (Denmark), Calon (UK), HiTECHnologies (Netherlands), Ciac (France), TLON GmbH (Germany), L.A. Electrónicas del Vallés S.A., IBT (Suisse), Connecting Intelligence (India).

Infranet offers solutions based on the LonWorks technology. Infranet links infrastructure components (sensors, actuators, controllers) within a machine, a building, or an industrial process. Infranet partners provide the know-how of building up such a network; the production of sensors and all parts needed for such a network and the implementation skills. Infranet was founded and organized as a virtual enterprise from the very beginning. Each company is completely independent, though a replacement of single partners is quite difficult in this very specialized field of work. A successful collaboration is hard to find in the field of LON-technology. Therefore the market situation is quite good: any opponent would need a lot of specialists and at least a lot of strategic allies in the different regions of Europe.

The Infranet partners employ a large number of specialists in the area of LON-networks. The widespread consortium allows them to access markets worldwide and enables them to acquire a broader range of orders. The biggest problem for Infranet seems to be the communication, as partners have to deal with seven different languages and cultures. The coordination of the projects is usually done by phone and e-mail, as only part of the collaborating partners are using common CSCW tools. A frequent meeting of the project partners takes place about every two months in changing locations.

2.4 Nike

The cooperation of Nike and its Asian suppliers is a well-known example for a Supply Chain Management network. This kind of a virtual organization can be found especially in the old economy due to the fact that product changes occur slowly but in a constant manner. Building quick and flexible project teams is less

important than trying to reduce production costs. Some enterprises not even possess production facilities; instead they focus on marketing and quality management. Nike has competencies in marketing, design, and production. But the main share of its production is based on a network of Asian suppliers. Nike is a famous brand for consumer goods (shoes, clothing). It sells its products in the whole world, but only a small part of the products are produced in Nike's own factories. Asian suppliers produce (or partly produces) the biggest share.

Nike manages the supply chain and decides on design and quality. The suppliers are independent and produce in the name of Nike. Nike sells these produced goods in its name. Even though production in a convenient way would be possible in Nike's own factories, this model offers several advantages for the American company such as lower fixed costs (e.g. low personnel costs in China or Korea), a scalable production capacity, and a reduction of the risk in investment. Even for the suppliers such a network offers advantages such as an increased order security and no costs in design development. Problem can be seen in the strong dependencies of the suppliers from Nike and the quality measures.

This model can be found in many companies of the so-called old economy. Such basic form of collaboration was more or less established with the first outsourcing approaches.

Other clothing manufacturers, e.g. Puma use very similar network pools of manufacturers in low-wages countries, while new products are still designed by the central partner itself.

3. IDENTIFICATION OF CONVENTIONAL ENTERPRISES THAT WOULD BENEFIT FROM TRANSFORMATION

According to one of the common definitions, a Virtual Enterprise is distinguished by the following characteristics:

- Legally and economically independent enterprises co-operate in order to develop, manufacture and sell jointly products and services on the market and share the risks and yields incident to this business.
- Each member of a virtual enterprise concentrates on its core competencies and pursues the strategy of extensive outsourcing.
- The solidarity and the congruence of objectives are not achieved by legal contracts but are based on a common business comprehension.
- Due to changing qualitative and quantitative market requirements a strong customer orientation leads to individualising of products and services.

In the following we identify industrial sectors that seem to benefit from a transformation according to the rules mentioned above.

3.1 Building industry

Different people usually execute the different tasks in an architectonical project. Those have to work hand in hand, which means that their cooperation has to be well

organized in order to guarantee success. In the usual, simplified way this means: a team of architects creates the plans for a new project. The client has to accept those plans; afterwards they have to be approved. Again it is the architects' task to award contracts to constructors and suppliers and to supervise the whole construction phase. Communication between the different actors is of high importance for the realization of the plans. Upcoming questions have to be answered immediately, material has to be ordered and delivered. It is a reasonable approach to create an ad-hoc network for such a task containing architects, material suppliers, the applicant, constructors, ...

In Austria, such a consortium called "Cooperative Südburgenländische Handwerksbetriebe" (www.diecoop.at) was built up in 1999. 14 enterprises have joined the organization. Partners are electricians, joiners, glaziers, architects and other manufacturers needed to build houses. In Germany, we found an example in Kiel called "Spektrum-Raum" (www.spektrum-raum.de). The involved parties profited from competitive edges, reduction of fixed costs and sales increases. The reasons why this cooperation form was realized are well recognized in the whole building branch. The order situation is very unstable. SMEs have to face the problem that they cannot act as "general providers", that means a customer cannot get the fulfilment of his whole order out of one single hand. This is the reason why many SMEs remain in the status of a strongly dependent supplier. The creation of a virtual organization in this area offers lots of advantages. First of all, customers can get the whole product range out of one hand even though the network partners remain legally independent. They all concentrate on their core competencies, which allow introducing innovations quickly. Risk is split and shared over the shoulders of the whole network; the amount of partners allows a higher market presence. The occurrence as a network strengthens the organizations' position in negotiations and a common project management helps to lower costs and to save time.

Thus, all involved parties are informed about the actual needs or problems. Questions can be posed and answered, needed material can be supplied without any time delay. Considering a virtual marketplace, materials can be bought from the cheapest supplier. We expect a high impact if such a consortium is transformed into a virtual organization.

The "Cooperative Südburgenländische Handwerksbetriebe" works with great success. In the first year the consortium acquired nine orders. The total revenue of the consortium was higher then the volumes of the single manufacturers. Thus, the "Cooperative Südburgenländische Handwerksbetriebe" can be seen as a reference model on the business field of house building.

3.2 Traditional manufacturing industry

Reality shows that the differences between a working supply chain and the concept of a Virtual Organization are small. Main differences can be found in the IT infrastructure, the strong asymmetric dependency and a lower communication level.
Let us consider the supply chain for a car manufacturer, e.g. DaimlerChrysler. A car manufacturer has a pool of e.g. 100 component suppliers, e.g. Bosch, Becker, ... Those suppliers are permanently evaluated according to the quality of their products, their timeliness and so on. The best-evaluated companies get the order to supply the car manufacturer for a certain period, but are in permanent competition with the

other suppliers in the pool as the latter have the permanent chance to get a higher ranking. This permanent pressure on the suppliers to deliver high quality components, to offer best service and to supply the purchaser in time gives the purchaser – in our case the car manufacturer – a strong position towards the pool of suppliers.
That way, an existing supply chain corresponds with the concept of our Virtual Organization. The transformation from a "soft" VO into a "hard" VO can have impact on costs and time.

It is worth to find out how a common ICT-infrastructure, a common corporate identity can have impact on the function of this supply chain, e.g. in terms of costs and quality. The implementation of a kind of "virtual marketplace" seems to be a promising approach.

3.3 Trade organizations

A special kind of supply chains is trade organizations. Wholesale dealers buy goods from the producers and deliver them to retailers. Logistics are involved, as they have to ensure the accurate delivery of the goods. Retailers appoint agencies to create advertising campaigns. The heterogeneous actors are closely linked with each other. A common platform should be installed which provides information about the offered goods, about the delivery status, about prices from different wholesale dealers and of course the possibility of buying and selling online after a comparison of prices.

The transformation of trade networks into virtual organizations is a highly interesting field. Expected benefits are lower purchase prices, high market transparency, quick delivery of goods, and high flexibility in the choice of business partners. We also expect positive effects for the customers, e.g. lower prices, better quality, and a bigger choice. Thus, customers as well as the organizations are expected to profit from the transformation.

4. POTENTIALS, INHIBITORS AND CHALLENGES FOR THE ADOPTION OF THE VIRTUAL ORGANIZATION CONCEPT

In this section we summarise a list of drivers that are expected to play a major role in adoption of VO practices in short or mid-term. At the same time, inhibitors that hinder extended collaboration practices are described. Drivers as well as inhibitors have been identified during an empirical study in the area of Baden-Wuerttemberg [1].

4.1 Potentials

4.1.1 Increased flexibility

- The combination of several enterprises with different core competencies leads to synergistic effects that can boost new market development: Virtual

organizations can react faster and more flexibly to changes in the market. The speed of changes in the market and changes in the customer's behaviour lose importance as a virtual organization can offer a broader range of products with much higher flexibility. As customers expect complete product portfolios, the joining of a VO offers SMEs a great chance to satisfy those customers' needs.

- Virtual Organizations can change their market focus much quicker than their "traditional" competitors as they have knowledge in different core areas spread over the business partners. So a fast reaction to changing market requirements can be realized. Changing dynamics do not have to be seen as a disadvantage any longer, as they can be a competitive edge against lumbering competitors.

4.1.2 Cost reduction

The positive effect on a company's costs is very obvious, as the costs for the development of new products can be shared among the partners. In many cases, it will not be necessary to begin the development from the scratch as for one or a few of the network partners the required basis skills will be available which would have to be gained expensively otherwise. Especially when it is about large and expensive projects (e.g. the former Airbus-consortium), this is an important advantage against "traditional" competitors. In this way, even a network of SME's gains the ability to compete with large, worldwide-acting enterprises.

4.1.3 International presence for SMEs

Nowadays, international presence is crucial for the majority of SMEs. Joining a virtual organization, opens the gate to the markets of the collaborating companies– possibly located in different countries or even worldwide. Each network partner of a virtual organization gains access to a far larger market than he could develop on his own. This allows companies to enter new markets by using the contacts of their network partners. The typical barriers companies have to overcome in order to access new markets become much lower. This offers new sales potentials – for the virtual enterprise as a unit, as well as for each network partner. In addition, the adoption of the VO concept helps SMEs to rise from small, minor competitors to a network, which can be seen as a global player on a global market.

4.1.4 Realization of time advantages (Time-to-market)

A network of different companies with different core competencies offers a broad variety of material and personnel resources. This leads to a faster development process of new products or services and allows the competitors to react faster on changes on the market (compare to "increased flexibility"). Adequate staff will be available any time, material and knowledge resources will exist in at least one of the partner companies. The virtual enterprise has the possibility to react to an order from a new business field, or even to new market demands without the need to employ new specialized personnel, which is indeed a time and resources consuming process. This allows for a quicker reaction to market changes.

4.1.5 Access to external knowledge

Depending on the type of VO, collaboration in virtual networks offers companies the chance to access the knowledge pool of their partners. Of course – this can only happen under the condition that partners in a network are not direct competitors outside, e.g. they need to have access to different markets or offer different core competencies. Even in a virtual organization, the interests of the individual company stand in the foreground. But in case network partners are able to share their knowledge – sometimes even confidential information – this will have positive effects on trust building as well as on the effectiveness of work.

4.1.6 Coping with changing dynamics

A striking challenge in today's business world is the changing dynamics within the complex relationships of the organization, its workforce, customers, and suppliers. The most dramatic change that shows up on the news is a massive lay off for the purpose of downsizing. Less visible to the general public is business process re-engineering. Many companies are re-orienting themselves in order to cope with changing dynamics. With support of Internet-based communications and information transfer technology in order to maximize corporate resources and satisfy a common pool of customers, the concept of the virtual organization is a good possibility to respond to the changing environment. The virtual organization uses technology in order to create new, possibly temporary, arrangements among employees, suppliers, customers, or other important partners, and for fast exploitation of new opportunities with greater efficiency and lower cost.

4.1.7 Effective knowledge management

Knowledge (whether it is inside the mind of an employee or a customer) is increasingly important to today's highly competitive organization. Any methods for more effective use of information and knowledge can enhance competitiveness in a world market that has no mercy for weak or slow competitors. A common knowledge management system, which integrates the information of all network partners on a common platform, can help to achieve this goal. As a benefit, decreased research times, higher effectiveness, and an increasing common culture of trust ("we share confidential information") will be created with positive effects on the value creation.

4.2. Inhibitors and Challenges

4.2.1 Clear Organization

Organizations that have an aversion to risk and demand certainty of outcome will find it difficult to pursue a fast track strategy, but will rather stuck in conventional project processes. Simple, clear organizations that are devoid of rigid hierarchy and operate on the basis of openness, trust, mutual support and empowered team members are most likely to be more successful, hence selecting fast track projects based on organizations also plays a critical role in implementing one. Thus,

contractual arrangements are required, that align the client's objectives with the interests of all the parties, who need to co-operate so as to achieve those objectives. Project risks need to be fully understood and placed with the parties who are best able to manage them.

4.2.2 Adequate Workforce

People and their relationships will have the greatest influence on the success of the project, so that great care should be taken in the appointment of the key staff for the virtual organizations. In practice it is rarely possible to select the best people for all roles in a particular project and an integrated team approach is recommended in which everyone is able to contribute to the limit of his/her capability and the team, as a whole, covers for any shortcomings of individuals.

Not every network partner represents a gain for a virtual company. Let us remind ourselves of which criteria a member of a virtual organization should fulfil for a gain to be achieved. Complementary core competencies are most important, but also social competencies, access to different markets, and the possibility to build up a common cultural base cannot be neglected. Even if those criteria are fulfilled, it is possible that some partners weaken the whole organization instead of offering further benefits. When choosing the partners, the focus should be on the complementarity and compatibility of the partners and not on existing social contacts or business relationships. The use of a collaboration process results from the ability of cooperation, the willingness to share information and knowledge, and the readiness to take responsibility in core competencies. If problems in these areas are detected, the members of a VO have to be ready to re-structure their organization, including the exclusion of some current partners and the affiliation of new members. A VO will always be a dynamic kind of organization, which of course can also be seen as a motivation for the network partners to show maximum dedication.

4.2.3 Finance

Cash flow problems are a common inhibitor of progress. Since fast track projects are associated with frequent changes, special arrangements should be made to ensure that work is not interrupted while awaiting funding approval and can proceed at a maximum pace supported by the necessary level of funding. Especially the demanded high investments in IT-technology are a high risk because no one knows about the success of the virtual organization.
A company does not know for how long it will be part of a virtual organization. At the beginning it is uncertain whether the cooperation will be long- or short-term. Required investments are a barrier to enter the network of companies and possibly also a barrier to leave again. This possibility always has to be taken into account, as a virtual organization is no guaranteed way-to-win for every company.

Considering the specific problems of SMEs, it seems to be important to implement financial support programs on a European level. In the current turbulent economic surroundings, the ability to invest or the willingness to take high financial risks is low especially in the field of SMEs.

4.2.4 Communication

Barriers to communications should be removed even though high cost is associated with fast track projects, it must be broadly defined in such a way, that information flows directly between all affected parties regardless of parent organization and hierarchical level in the organization. Prioritisation should be given to IT systems on whole and the level of integration, covering information sharing and reuse. To integrate different communication politics, it is necessary to fix communication rules. It should be fixed in which case to use which kind of IT, in which time mails have to be answered, whether virtual conferences are needed, etc. Those rules have to be mandatory for the whole VO. That way IT can support the process of building up trust in the demanded way. The communication guidelines need to be checked from time to time. Together with the point above the suggest actions help to close the gap between reality and vision on the IT infrastructure focus area.

4.2.5 Loss of competence

As partners in a virtual organization should be in a complementary relationship with each other, it seems to be possible that one partner only concentrates on its most important abilities and disregards other competencies. But if one partner concentrates only on its core competencies, this can result in a high dependency on the other partners. The result is the loss of competencies in other business fields. As long as a partner is a member of a virtual organization this problem will not be visible, as other partners in the ideal case can compensate the loss of competency. But after the end of the cooperation, partners who neglected special topics of their business will have to face big problems. It will be very hard to catch up the competitive edges of their competitors.

4.2.6 Development of the partnership

Because of the regional distance, it is necessary to work hard to grow together as one virtual organization. Otherwise the risk for single partners to get separated from the network seems to be quite high. Personal talks, videoconferences and intensive contacts with the partners help in finding a common identity and in building up trust. The development of a "togetherness-feeling" is an enduring process, which can only marginally be influenced by explicit external actions. At the start-up of a VO every partner will be quite careful regarding trust and communication. Every partner will carefully observe the others and draw conclusions. At the moment were a VO becomes static, the failure is close. The relationships in a network system need to be dynamic and "alive" to overcome the differences between the partners and develop the partnerships.

4.2.7 Low acceptance

A missing corporate identity can have a large effect on the acceptance of virtual organizations. In a VO several companies or freelancers come together under one roof. From an internal point of view, there are still legally independent companies

with their own management. But from an external point of view, this should be different. Reality shows, that a main difficulty is a missing corporate identity. When a VO is addressed from outside, the question is "Who do I address to? Who is responsible?" This problem should be overcome by installing a central contact point that every external interested person can contact. The development of a corporate identity is of high relevance for the VO's external affairs communication. The structure of the VO is irrelevant for a potential customer – so confusion about this should be avoided. Furthermore, it must be clear who is legally responsible for the actions of the VO. If the VO acquires an order, the customer needs to know about the legal consequences, as it is a matter of fact that legal security helps to build up external trust.

4.2.8 Intellectual Property

Traditional employment rights and obligations have been based and developed in an industrial age in relation to concepts of unfair dismissal, collective rights, discrimination, redundancy, and health and safety. Although these are still relevant in an information age the nature of the employment relationship is changing, particularly because of the way that new technology can transform the workplace and the work environment. The fact that we can now have the virtual organization with little or no physical establishment makes it necessary to examine some facts according to intellectual property rights. Who owns the information assets of a virtual organization then?

5. CONCLUSIONS

Industrial experience shows and best practice in the area of VO proves feasibility and practicability of VO approaches. Several branches have already adopted the extended collaboration processes (i.e. building industry, traditional manufacturing, trade organisations) and are ready to proceed one step further, in order to transform their business into a part of a virtual enterprises.
Increased flexibility, extended knowledge, potential to gain time advantages as well as coping with changing dynamics are some of the drivers of the transformation, while the importance of each driver is related to the specific business area.

A branch independent driver is a side effect of market globalisation. VO concepts open new markets for network partners. Collaborating SMEs evolve from being a small, minor competitor to a network, which can be seen as a global player on a world market.

On the other hand several inhibitors have been identified, that are hindering the adoption of VO concepts. They comprise risks in the areas of management (organisation, finance, workforce, loss of competence), people (corporate identity, communication) as well as legal issues (i.e. IPR). It is symptomatic for this area of work that several of the inhibitors are challenges at the same time: development of a lean organisation structure, hiring of adequate workforce and maintenance of partnerships will increase efficiency and maturity of the company.

Future legal, R&D as well as dedicated dissemination or training activities should consider these challenges and turn them into opportunities that will facilitate transformation, especially in the area of SMEs.

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VIRTUAL ORGANISING SCENARIOS

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Scenarios can help to understand future developments and their potential implications holistically and thus augment analytical approaches. This chapter presents three scenarios, depicting different, but complementary forms of virtual organisations: regional clusters and enterprise networks, professional communities, and global networked firms. It analyses the forces at work, which potentially drive developments towards these forms, and the impact on different business processes. Researchers can distil research questions and use cases from the scenarios, while managers can use them as backlight against which they can develop their long-term plans.

1. INTRODUCTION

Imagine that it is now the year 2020....
The objective of the here presented scenarios is to distil current views on IT driven organisational changes and to make general expectations of future organisational developments explicit. At the end of the Internet hype, many of the optimistic expectations are disappointed. Yet, the motivation for these scenarios is that especially in times of crises persistent believes are formed that will shape growth and development thereafter.

These scenarios focus on organisations – mainly on the organisation of business activities but also beyond. For a decade or so, the emergence of very adaptive, non-hierarchical forms of networks is predicted (Laubacher and Malone, 1997) – for which we use the term virtual organisations. We refer to virtual organisations not as 'a' new form of organising but as a set of organisational principles that can be expected to replace those principles of the industrial hierarchical firm that were established about a century ago. Virtual organising will change each individuals working and living (Barley and Kunda, 2001) when they 'enact' the organisation (Kraut et al., 1999). While our level of analysis is on the organisational level, we will for this reason often use the concrete description of illustrative examples of individual action.

The scenarios are the results of a two-year research process, which has involved literature research, review of engineering developments and expert workshops. Involved researchers have been studying virtual organisations for almost decade and a dedicated Centre of Competence at CeTIM involves industrial companies and researchers. The scenarios combine findings from numerous vision-building processes and road mapping activities for new forms of organisations both within industrial firms or clusters of firms.

The intended contribution of this work to research is to establish a research agenda of relevant future issues. For practicing managers this paper aims at providing guidance for long-term decision making (Lebeer, 1996). Overall, the work is therefore undertaken in the hope to narrow the gap between academia and practice in this field. The paper is structured as follows: In the next section three scenarios are introduced. Subsequently, the driving forces behind their development are summarized. Chapter 4 then discusses the impact on the main business processes in future enterprises. The paper concludes with a view on current organisational developments and future work.

2. THREE SCENARIOS

The regional cluster and enterprise network

Imagine that it is now the year 2020…

Most SMEs (Small and Medium Enterprises) have their own 'homes' – 'regional enterprise networks' or VO breeding environments. Few large, global companies are still in existence, focusing mainly on product and service integration and worldwide branding and marketing. They provide the large financial funds and global distribution networks, which are needed for fast introduction of new products. Small firms or networks in high-tech regions, however, provide innovation itself. To them, the large international groups provide development roadmaps and strategic guidance and they are customers of the innovative products or licenses.

Networks will consist of partners that mutually adapt their strategies and develop strategic profiles or roles [Miles, 1986 #123]. This allows each partner firm to develop a consistent set of organisational routines and competencies. Cooperative strategies are established on network level, where dedicated routines and decision-making capabilities can be observed. Examples of profiles or roles within networks are recognizable and include:

Brokers or business architects, in charge of order acquisition, network marketing and internal assembly of the best project teams for the orders. Project managers, coordinating the different projects and the partners involved for successful delivery, supported by advanced information technology that reduces the transaction costs and enables the seamless cooperation among SMEs. Network coaches - often public agencies or regional schools – maintain education and regional development and coach new partners. Auditors evaluate partners' operative and financial performance. Further partners provide specialized services such as information system implementation, legal advice or social security.

Competition mainly exists between different networks, often on global scale as many products and services can be sourced from almost anywhere. Competitive

forces will also translate into internal competition between the companies of the network. Each broker needs to make sure to contract the best resources for a compatible price to fulfil customer requirements, just like brokers have to compete for valuable and scarce resources of the network. In short, networks that do well show more balanced internal cooperation and competition mechanism than those that suffer from apparent defects. It is the role of network coaches, but ultimately of each network partner to develop the network to improve its competitiveness.

There is an intensive exchange with the large international brands that search new technologies and products in innovative networks. When innovating today, you really want to be part of all the right circles and profit from the differentiated services and support of university research institutes, public or private incubators and their early legal, managerial and financial advice, discussions with business angels and later venture capitalists. They all help shaping strategies and roadmaps of future developments that finally leads to high growth – and personal wealth of the successful developers and innovators (Markus and Agres, 2000):

Imagine a member – we will call him Jack – of the 'Broker Services' of a regional manufacturing network. There are about 50 companies in his regional network, employing a total of more than 6,000 employees. As such, they could have formed a single integrated company in former times, but they are much more agile and entrepreneurial as independent, though collaborating firms (Katzy and Crowston, 2000).

Their core competencies lie in the areas of engineering and manufacturing, such as mechanical processing, metalworking, surface treatments, heat treatments, plastics working, and electrical and electronic engineering. The regional network offers complete solutions and services for larger assemblies and for sophisticated components and replacement parts. The responsibility of the 'Brokers' is to market the network competencies, acquire new orders, and assemble the partners' competencies and contributions to fulfil the orders.

Every day, the first task for Jack is to log onto the virtual collaborative platform to check whether there is new information on orders. There are 3 channels to obtain orders for the network: first, Jack can bid for orders from large, global companies, as the regional network currently provides some products and innovations to them. The brokering support system is connected to the relevant purchasing systems of the different global players, and Jack frequently checks for opportunities, analyses the requirements and organises the network partners to bid for these orders. Second, order information can come from internal network members, as they are approached directly, but sometimes cannot fulfil by themselves or know that the network can better provide the required competences for the order. The partner can post the order information to the broker and other partners through the information platform. Third, Jack routinely markets the competencies of the network, and gets orders from direct and indirect contact with customers. Jack is in the industry for more than 10 years, and he knows quite well about the industry developments and trends.

The other task for Jack it to marshal the right competencies within the network to match the orders. Jack understands very clearly the partners' capabilities and updates his knowledge through frequent meetings with partners and timely information, such as performance data, filtered for him by the network information system. Normally, Jack analyses new opportunities, and then looks himself through the competence database of the network to find out the members who possess the most important capabilities, as there is also a lot of judgement involved. Based on

the performance rating and his own knowledge, he sends out the information to these network members and asks them for feedback. He also involves one of the project managers, who are mostly independent partners in the network, providing professional project management as a service. They usually arrange a virtual meeting with the partners within a few hours to discuss the prospects and assign elements to the different partners for concurrent engineering to shorten the proposal and later the development time. After the meeting, Jack publishes the order information in the collaborative system and calls for other peripheral partners to join this project.

There is an executive committee conference and 'network day' for all members twice a year, and working group meetings for specific topics every 4-6 weeks or more often if required. Jack has the closest contact and overview of the global market. He therefore has an influential role in the discussion with other executive members and partner representatives on how to position the network in the global market, how to improve network performance and how to manage innovation in the network etc. But other partners contribute to the discussion as well, as they have a vital interest in the right development direction of the network. But they do no longer develop operative annual plans since turbulent market environment render them obsolete within a few weeks only. Instead, they concentrate on topics such as differentiation from competing networks, competence development in the network to meet market needs, new partner inclusion and partnering agreements with other networks or global marketers, and extension of their collaboration platform and collaborative processes.

In the coming executive committee conference, there will be reports from the Brokers, Project Management, Training Group, Audit Group etc. to address the different aspects of network development. The representative from the Regional Development Agency also attends the conference; he will make a report on governmental development actions and social support systems.

Jack will do the report for the brokers, additional to summarizing last years' work, he will propose some key points for discussion:

- The network positioning strategy, as more and more similar regional networks enter into the global market, the pressure for getting orders is higher than before. Jack considers it is necessary to adjust the network strategy, especially in the areas of innovation and adapted services.
- The rules for recruiting new partners, as the markets demands changed to some extent during the last year or so; there is some demand for complementary competences that the network does not yet possesses. So he proposes to recruit two new partners.
- The continuing cooperation with the regional development agency; he proposes some new, joint training and regional infrastructure development scheme.

With many years' experience of being a broker in regional networks and in the global market development trends, Jack believes that the environment for SMEs to survive is much harder than before. The regional network offers one feasible solution for SMEs to grow, as they can focus on their core competence development with the support in most other areas from the network.

Professional virtual communities

Imagine that it is now the year 2020...

Martin belongs to a group of professionals for whom the term "knowledge worker" has been coined: Martin is a designer for screen user interfaces, which have become extremely common in recent years as so called ambient intelligence, e.g. for information, communication and control purposes has become very popular. Martin has a lot of knowledge and experience on how to make these user interfaces very intuitive and easy to use even for older people, but still give them the powerful functionality necessary. Until a few years ago, an appliance company had employed him, but the interface design had been only a small part of his job, so he could not develop a deeper competence in it (Pirinen, 2000). Martin has left the company some 5 years ago, as many other colleagues in the product and process development departments to work as independent "knowledge workers".

Martin now has developed a distinctive competence in the interface design and works for several companies, or better to say networks, since most of his customer companies work in networks themselves. He has joined the local community for multimedia and virtual reality design, which works almost like a guild in former times: The members agreed on a minimum fee for their work services to also pay for social security and training and on basic rules for professional conduct. The guild was initiated and supported in the beginning by the regional development agency to strengthen the local innovativeness and prosperity. Although there are regularly attempts by some to work outside the community, most try to join in when they realize its benefits. The community also offers brokering services to manage the transitions of discontinuous projects (Watson-Manheim et al., 2002): The leadership team knows quite well the competencies of the members and can market them on a wider scale. They have links to local networks as well as to many of the global companies that nowadays predominantly act as marketing and branding organisations, and of course as co-coordinators of local producer networks. One of the main tasks of the leadership team is to support a well-balanced development of the network (Ahuja and Carley, 1999). They know that they compete with a few other groups in Europe and worldwide, so they define strategies for their positioning, skill development of the members, performance measurement and rating, and well-balanced cooperation and competition within the network. The members select the leadership team for two years and they have a strong interest to get the best people into this important position.

Martin mainly gets his new projects through the portal of the community, which he scans through every morning, or through personal contact, directly or through his "team", close colleagues and friends with whom he works more regularly. They are a closer "home" within and beyond the community. They all have their field of expertise, e.g. three doing programming, another one is expert for the user interface hardware and two for the integration into the appliance. Depending on the project, they together decide who should or can join in. Although people have thought in the beginning of the 21st century that with the new communication technology firms will often switch the people they work with in projects, happy customers are still likely to come back. They might experiment from time to time, but even then they usually rely on the services of the guild to find the right people for the job.

Let's imagine a typical project for Martin: This morning, he has seen an interesting invitation for tender on the community's portal. His intelligent agents can

filter quite well interesting projects, but Martin often wants to look also for some interesting projects besides his core field, to tell his friends, but also to keep up to date with the market. He marks his interest for the tender and gets a personal login for the basic project information. He can also request a virtual meeting with the project manager to clarify some details of the project. Martin then decides to ask some of his friends to join in for the proposal. The messaging and conferencing possibilities together with shared electronic paper have been actually one of the biggest steps towards an effective coordination in the team and most projects (Haywood, 1998). You scribble a remark or little drawing on the screen, and everybody else in the conference can see it. Although two of his colleagues are away, he can quickly co-ordinate with them and sets-up a virtual presentation to the customer with some of their ideas for two days later – and they are successful! The new ideas, past projects as references and their performance rating in the community were the decisive factors.

However, for the actual project work, the external login to an information portal is not sufficient. They get a personal login and a configuration file for their design and collaboration software to participate in the digital master data of the project and the project management workflows. All systems now provide much basic collaboration functionality, which can be very flexibly configured to the purposes, but the people are still the main actors in all relevant decisions.

As this is a rather large project, during the project kick-off all people of the project – about 60 people, 10 independent knowledge workers, the others from 16 different companies – come together to meet one another and to define the rules and processes for the project. After some discussion, they agree on a common collaboration framework, with which most partners have had already good experience in former projects. During the project, most co-ordination can be done through virtual conferencing and the workflow support, or in smaller sub-teams. Martin can even go with his family for three weeks to Mallorca where he often has his best ideas.

He owns a nice, small cottage on Mallorca, his "reward" for an innovative idea he and his friends developed two years ago. They jointly developed a prototype, which they offered through the guild's brokers to some of the global communication equipment companies. Nokisco, the merged Nokia and Cisco companies, took it, found further engineering and manufacturing companies joining in and brought it onto the market within two months – and it was a good success even in China and South America.

The global networked firm

Imagine that it is now the year 2020…

Nokisco is one of the now typical large, global firms. It emerged out of the merger between Nokia and Cisco already more than a decade ago, when Nokia wanted to push forward the complete integration between mobile and line based communication and data exchange. They now provide all kinds of devices and infrastructure to almost any commercial customer and end user in any region of the world.

However, despite their impressive turnover and business reach, the number of employees directly employed by Nokisco is now little more than a quarter of the

former workforce, and this after more than doubling turnover. This development started with the consequent outsourcing of the traditional support functions such as accounting, human resource administration, logistics, facility management etc. But Nokisco also had difficulties to constantly reorganise the development departments to keep the pace with the integration of new technical and software developments and to handle the ever-increasing number of projects and products (Majumdar, 2000). So they moved more and more towards external technology consultants and developers, co-operation with research institutes and universities, or even buying innovative licences or products from external suppliers. A similar process set in in the area of production. As new technologies required too high investment, but also due to the high demand fluctuations it did not make sense do keep much production in-house. And even service projects for other customers are staffed with many external team members. Thus the main task for Nokisco is a global switching platform of various supplier activities to meet customer demands (Mowshowitz, 1997).

The added value of Nokisco's in-house competencies is to assure fast product introduction and reliable quality of all services and products on global scale to meet the brand standards. Highest degrees of automation across the entire supply chain allow for low cost of operation and mastered quality. High automation further allows for the very rapid scale-up of any new business. Web-based order management, product documentation, and sales training in all relevant languages and with limited adaptation for national markets can synchronously be made available on the web pages.

Capabilities at Nokisco therefore include what is necessary to solve the problems associated with marketing, roadmapping and forcasting, new business development, supply chain management, supplier relationship management, contract management, web-based process design and automation. These allow Nokisco to develop and introduce new products within less than six month and ramp up necessary production scales. Systematic new product introduction achieves on average a complete overhaul of the product portfolio every 18 month.

Even internally, Nokisco resembles more a virtual organisation than a hierarchical firm of 50 or just 20 years ago. As most routine jobs are either outsourced or automated, most value creation happens in those design projects and product management teams that guarantee permanent renewal of the product portfolio and the fully automated global order processes. Since many processes and constellations are constantly changing, design, problem solving, and project management are however still human-dominated. Beyond the teams, there is little formal hierarchy. Mentors support employees and coach development paths of their careers. A competence management system helps to find the right people and to support individual competence building, but there is still a lot of personal recommendations and contact involved in the team assignment.

There is fierce competition between the large, global companies in their respective industries, and each has to make sure that they provide innovative products and comprehensive services tailored to customer wishes and requirements at competitive costs. Those large firms are strong bargainers against local network suppliers or independent knowledge workers. Their high integration and easy configuration of information and communication systems, however provide global leverage and reach that no regional network could get on its own. But there are factors that counter balance their scales of power: Innovation and customer service

are important success factors on the global market and typically reside with local networks.

3. TOWARDS SCENARIOS OF FUTURE ORGANIZING

Driving forces

Scenario planning begins with the assumptions that the future cannot be known with certainty and that the future is not a simple extrapolation of the past. However, scenario planning presupposes that there are driving forces, which will shape the developments for the near future. Driving forces are 'weak signals' and our research group has set out to gather a lot of material through different projects in the field, in multiple meetings and workshops with experts, researchers and practising organisational leaders around Europe, the collection of Delphi survey material and so forth. The main driving forces could be summarised as:

Changing attitude towards 'work'

The understanding of what 'work' actually means is changing. Weber's fundamental writing about organisations dates from the early 20th century, when work mostly was physical and manual work that was undertaken by a rapidly increasing formerly agricultural workforce that had to be trained and monitored by the few skilled scientific managers in industry. Increasingly so-called knowledge workers are highly educated experts in their respective fields. They are capable of planning their own work, and often that planning and adjusting is an essential part of their problem-solving service.

The changing context of work drives organisational change. Supervision through command and control, which is the basic mechanism of hierarchies, is applicable to the industrial work of the early 20th century, but much less to knowledge workers. Knowledge workers usually work in smaller teams of 5 to 10 people or even on their own. Often, they come from different companies or are self-employed as contingent workers, but even large companies now move to resource pools with little hierarchy or coordination outside project work. These knowledge workers need other coordination mechanisms that allow bringing their problem solving competencies into decision processes. And their relationship with one project is limited to the time that their knowledge is needed. Change is no longer a threat only, but provides opportunities for individual development.

Such work conditions rather resemble craftsmanship conditions than industrial working conditions. Therefore guilds, a European cultural heritage, or professional communities seem appropriate to serve as an additional level of organisation besides the project-oriented level, to support knowledge building, social contact and relationship, and life maintenance.

Increasing relevance of specialization and expertise

With increasing (computer) automation, copying or doing the same activity again becomes ever easier. In economic terms, lesser value is added by copying. Building a second car of the same type requires much work and material, making the second

copy of a computer program does not. In other words, combining production factors, which was the mechanism of adding value in the industrial age is making place to innovation as the value driver in the knowledge age.

The business impact is that organisations more and more concentrate on core competences and focus on problem solving capability. Competences develop in small but stable organisations over long periods of time (some claim, building distinctive competences takes more than a decade). However like with individual skills, competences are needed only for limited periods of time in one context, and then are free to be applied in a different one. Some writers even claim that competencies only develop through knowledge application in different settings.

In other words, competence centres need multiple relationships with other partners to enable shifting cooperation, which is described with the metaphor of a network. They further need special networking competences to build networks, to find a position in a network, or to create new contexts and constellations.

Reducing the function of the business firms

Organisation and management theory made its biggest progress to explain the functioning of the large integrated firm. Such firms assumed many functions, above all of course, business functions for the introduction of new products, manufacturing and sales. But there are many direct and indirect support functions, such as logistics, accounting, IT services, facility management that were or still are integrated into the firm. But companies are outsourcing boldly such functions and thus develop growing networks of firms.

Besides this, many firms assumed numerous social functions such as education and training of the workforce, social security, employment and pension funds, housing, medical services, sports, cultural events and so forth. Firms, in short, became one central node of social live.

While social networks do not loose any of their importance, we expect firms to increasingly focus on a narrow set of business functions, while social networks strengthen within the regional context. For example, education and health services are supported by local public services, and employment is increasingly offered by temp agencies. Weekly working hours as well as the number of years with one employer decrease and reduce the relationships of each individual with a certain firm.

Management becoming a service, instead of a position

With organisations undergoing more change for rewarding opportunities, managerial capability will increasingly become a professional service to be provided under competitive conditions. The comparably stable social leadership position of a large and old organisation will increasingly be replaced by efficient, goal oriented coordination and management services, which can be an independent node in the network itself.

Partly this is can be attributed to the increasing computerization of coordination tasks, e.g. with SCM, CRM, or ERP. More efficient solutions will replace less efficient ones. Growth of business, however, will more and more become a function of managerial capability, to combine ambition with judgement, fundraising ingenuity, or the ability to marshal support from customers, suppliers and employees. Those businesses with global reach will need excellence in human and

computer coordination on a global scale, while most of production and service provision will remain local.

Globalisation

Globalisation has often been named as a main driver for organisational change, however without reference to specific causes. We see mainly two forces towards increasing virtualisation at work through globalisation: Global marketing and sales and – partly influenced by these – demand fluctuations. Global marketing and sales gives the opportunity to potentially reach anybody worldwide with most products or services. However, to provide the coverage, there is a need to cooperate for market access and regional service provision. On the other side, global market access brings about global competition for which innovativeness and adaptability – core elements of networks – are strong defences. Demand fluctuations happen through global adoption of products and trends almost at the same time. A well received product can achieve a multitude of the projected sales – needing a very fast ramp-up of production – while a failure can ruin a company that invested too much in production capacity. Again, networks of firms can mitigate these effects.

Other forces

A number of other forces could additionally influence the direction and speed of adoption of the virtual organisation paradigm. Some examples could be:

- The ability and willingness of people to change and work in a more flexible and unsteady environment
- The availability and decision mechanisms for capital flows. Will large companies or small networks be more favoured (Amram and Kulatilaka, 1999) by investors?
- The role of governments and regulators on international and European, national and regional level. Their direct support and indirect regulatory influence can have strong impact on different organisational forms.

Technological Discontinuities

The fast exchange and processing of information clearly supports the creation and effective operations of networks. However, it is not clear yet, which mechanisms and functionalities are real "killer applications" which change the way we interact and work, and which have very limited effects. Communication support such as e-mail, fax, messaging, groupware seem to have much stronger effects than automation or complex decision support, especially in future environments which are likely to change much faster than today. Further research is necessary to identify the most important drivers, but we would expect some breakthrough developments such as experience-rich real-time communication or adaptable working environments with seamless data integration across projects. Real time communication will create new communication pattern and therefore change the structure of organisations (DeSanctis and Monge, 1999, Wiesenfeld et al., 1999).

4. IMPACT ON BUSINESS PROCESSES

The scenarios already show some characteristics of the main business processes within a future economy and the roles the different type of organisations play within them.

Innovation, Product Development and Integration

We would expect an even stronger premium on innovations. They will be the key differentiator between different companies. Innovations can have very different origin, although much can be expected from company networks, professional teams or universities and research institutes. Exchange of ideas and informal discussions are often the most important drivers for innovation, thus the remaining importance of regions and clusters as breeding environments for innovation.

The actual product development is envisaged as interaction between the different levels. Smaller project could be fully handled by enterprise networks, while large scale projects, such as new car or aircraft development, large building projects or drug testing and introduction are more likely to be driven by global firms, however rather for financial than technical reasons, as the distributed aircraft development in Europe or the distributed development of the Linux system has shown. In both cases, projects are expected to be supported according to competence and resource needs from professional communities.

As the development process is supported by distributed data management connecting the different partners, integration of e.g. manufacturing needs and customer requirements is no issue. Even the project management could be outsourced to a professional as service provider.

Supply Chain Creation and Management

Most manufacturing will be done within a network of production sites. Although these can be quite flexibly restructured, some switching hurdles, such as adjusted processes and systems, and the building of mutual trust and reliance, will prevent constantly and completely changing supply chains. Instead, enterprise networks will provide a rather stable platform with concerted processes and systems and an own network culture. Within the network, supply chains can be flexibly instantiated and adapted on a project-by-project basis, while the network evolves on a much longer time scale. Similarly, such networks might qualify as long term partners for global firms, while individual projects and orders are placed short term.

While the supply chain creation for highly innovative or individualized projects is still a process driven by an entrepreneurial broker and the different firms, more standardised projects and the actual order management will be highly automated by IT systems. Networks will have to be compliant with the systems of large firms to be accepted as suppliers in projects.

Manufacturing and Operation

There is a strong trend towards smaller and more flexible production units, even for traditionally large scale operations such as steel milling or car assembly. The production capacity can be flexibly sold to different customers, as the Finnish

Velmet plant shows, producing the Porsche Boxter and the Saab convertible – very different cars – on the same line, with about 50.000 units in total. High investment or other specialised production facilities will be pooled within an enterprise network, or might even fulfil direct orders from outside. This reflects also, that manufacturing will in many cases not degrade to a commodity, but plays an important part in business activities – and manufacturing competence in product design and process planning cannot be separated from operations. However, the boundaries of manufacturing operations, traditionally a very closed or even shielded part of a company, will be opened and linked directly to other sites. Even workers on the shop floor will deal directly with other partners in the network, since the detour through the traditional hierarchy slows down processes and induces potential errors.

Service Operations

Service provision in its many facets will remain very individualised and knowledge intensive. Therefore, two strategies could be seen: Wherever possible, services will be delivered through remote services, such as machine supervision and maintenance via networks or remote help desks. If personal contact is essential part of the service, it will probably be the domain of members of professional communities.

Marketing

Strong brands will most likely remain the most important asset in a global economy. The triumph of such brands as Sony, McDonalds or Mercedes in virtually every global region underlines the power and strength of the global firms. The brand assures quality and transports values in a proliferation of choice. To sell products and services under such brand will be an important if not the most important sales channel for enterprise networks and professional communities, and access to global firms important tasks for brokers and strategic positioning. Microsoft or HP certified engineers or the soaring sales of clothing and lifestyle articles under car brands such as Mercedes or Porsche provide a first flavour for this development.

However, for specialised products and services, branding will be of less importance and a highly developed competence brokering function takes its place. And mutual acquaintance, trust, and successful results are not likely to loose their influence in business relationships, such that new projects will come through personal networks or referrals.

Finance

As mentioned earlier, the easier access to capital will be one of the stabilizing influences for large firms, beside their global reach of brand and sales channels. However, venture capitalists or specialised banks as capital brokers could provide funds to enterprise networks and professional communities. While many mechanisms of such funding for individual firms have been developed during recent years, their extension to networks of independent firms or even individuals still requires change in approaches and understanding. Regional development agencies or even governmental regulation could be pivotal for the development and introduction of such important schemes.

Coordination and Management

The mechanisms for coordination will dependent on the type of activity, but are characterised by the absence of traditional hierarchical coordination: The strategic positioning, organisation in networks and creation of project consortia will be driven by self-organising mechanisms – partly through market mechanisms, but often through dialectic negotiation and consensus building, e.g. within enterprise networks and professional communities. Brokers or network coaches can facilitate the process, but do not have control over the members.

Coordination within projects is driven by specialised and highly skilled project managers, who however will not be able to force partners, but have to rely on coordination and facilitation methods, authority through competence, and the interests of project members to achieve the joint and individual goals. Project management thus becomes a service for a network which can be exchanged if it does not perform as required. To gain efficiency of coordination, a network or community will set – usually negotiate – certain standards, rules and systems to which the members are expected to comply.

5. PROPOSED USAGE OF THE SCENARIOS

Many scenarios assume development (by design) towards an identified given target. Alternatively, we express 'driving forces' in a dynamic process that entails choices and cross roads in its future development. The respective status will depend on external influences such as economic cycles, political crisis and environmental developments. It is, for example, most likely that investment behaviour and collaboration in networks is influenced by the social and economic climate. Similarly success or failures of highly visible companies accelerate or slow down the change and adoption of the virtual organisation paradigm. All scenarios presented are therefore spotlights at some point in time.

The three scenarios are complementary and span dimensions of a consistent configuration of one future. Unlike other scenarios presentations [e.g. Laubacher, 1997 #92] these scenarios are not mutually exclusive alternative futures. Each one rather stands for an aspect or role and has a potentially successful business model; and thus is likely to be found in 2020. A dynamic and shifting balance between the different forms will evolve, in which traditional concepts such as economies of scale and transaction costs are probably less important compared to their innovativeness, agility, and the ability to motivate and inspire people.

Researchers with socio-economic interest are invited to use the three scenarios to derive research questions and research programs that enhance our understanding of emerging organisational forms. For engineering research and development the scenarios can provide likely use cases that guide the development of supporting IT infrastructures as well as planning and control systems.

Practical usage of the scenarios can be derived from the scenarios when they are used as a backlight against which firms and organisations can develop their long term plans. Similarly, the scenarios can be used by policy makers to develop research funding schemes.

In addition to further elaborating and validating the current scenarios, we plan to explore their implications for future research and developments. They shall also give a long term perspective and follow-up in the area of virtual organisations.

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EMERGING COLLABORATIVE FORMS

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This chapter is organized as a collection of cases, contributed by different authors, illustrating important R&D challenges suggested by emerging collaborative forms. For each example case a brief scenario is presented, the collaborative facets are highlighted, and the main research challenges summarized.

1. INTRODUCTION

Most of the literature on virtual organizations (VO) is focused on "traditional" forms of cooperation among enterprises. Many of the usually described examples are little more than simple improvements over supply chains. More recently the VO concept was extended to other types of organizations such as governmental bodies (e-government), educational organizations (virtual institutes), etc.

The possibilities offered by ICT (the wide availability of computer networks, computer supported collaborative tools, ubiquitous computing) and the already acquired experiences are having a catalyst effect in terms of "suggesting" ideas for new forms of collaboration.

Without aiming to be exhaustive, this chapter collects a number of examples of collaborative forms that raise new challenges in terms of modeling, infrastructures, support tools, and even the very understanding of collaborative networks paradigm and its operating rules.

2. COLLECTION OF CASES

Case 1: Maggie – managing the daily production of a short TV show

Maggie is an experienced TV director that daily manages the production of a 10 minutes short humor TV show to be broadcasted some hours after. The work of each day is a complex "project" involving various different contributions with extremely short "lead-times" and, quite dependent on the creativity of the several potential participants. The success of the "product" is measured by the audience shares and is strongly based on several factors: the choice of the subject (that should be related to some recent "hot" news); the "idea"; the text; the scenario; the musical background or songs; the actors.

For all these items, Maggie has a large set of possible contributors (both individuals and small companies). Some of them may be not available at the required time, others may be unable to give the right contributions. The critical issue is that usually there are only one or two days to produce the show. Some of the participants do not need to be physically present – in fact, many of them have other activities, and therefore quite often they are away. On the contrary, the actors and some technicians have to do their work in the studios.

Maggie is quite good in putting together the different "pieces" of a project and assigning and coordinating the different tasks (in this very short time), but sometimes she feels she could probably do much better. Being quite often forced to decide in a hurry, she doesn't use all the information she believes might be useful. She has already tried to have a more formal schedule for each project, by asking some of the people to attend the daily meetings. However this proved not to work, at all... creativity does not fit into strict schedules... She has also thought of "motivating" these people by a monetary compensation scheme, indexed to the number and "quality" of contributions. This was implemented through a kind of permanent "on-line" contest, but difficulties arouse in defining the rules, and in imposing a set of operational constraints that would make the thing practical.

People do communicate by "e-mail" and that is the way to exchange information rapidly. But quite often people do receive wrong messages, and some times they do not get critical information. Intermediate results of projects are seldom released in useful time.

Everyday Maggie has to do a lot of different things: assess the availability of the team members and the "quality" of their potential contributions; negotiate and outsource services (with very fast exchange of information); decide who is going to do what and when; guarantee that during the day, intermediate deliverables ("work-in-process") reach the destinations in good conditions (satisfying the requirements) and in time; control the global quality of the final result; eventually trigger "recovering procedures" to avoid and correct mistakes; compute the global direct and indirect costs of the project; "respond" to the participants' expectations, by adequately recognizing the Value of their work.

Collaborative facets

Maggie manages a dynamic co-operative network, working under an enormous time pressure and involving participants (individuals and micro companies) with quite different skills and competencies. Very dynamic "virtual teams" are daily set-up to organize, plan and execute a small but complex project. Most of the contributions are strongly based on creativity, making co-ordination even harder.

Fast and easy communication among the participants is very critical, as we are dealing with an iterative "convergent" process that may need a lot of feedback and many refinement steps. However there are still problems in defining the right levels of access to information and in setting up the right mailing lists.

Moreover Maggie soon recognized that the "supply chain" characteristics of this production process required a set of tough co-ordination procedures, somehow incompatible with a "free format" of individual contributions.

To make things more difficult, performance is assessed on a daily basis, by cost evaluation and by studying the public impact of the results.

Challenges

Maggie should probably keep the information of each project in a web based document management system, with tools for collaborative authoring and for workflow management.

She is really convinced that the "business" is about "information sharing", requiring that the right information reaches the right persons at the right time, with minimal confusion and perturbations. But she feels unable to manage things better.

Sharing information in a "controlled way", creating simple "monitoring" mechanisms, "promoting" decentralized and pro-active initiatives would surely help in achieving better results:

- improving product quality (larger audiences and larger advertisement returns);
- decreasing production costs;
- increasing the team motivation and participation.

Ideally some support mechanisms and tools could help in measuring and managing the contributions (i.e. their value) of each participant in order to facilitate proper rewarding.

Maggie believes that the participants in the team should have a more proactive attitude, understanding and sharing the common goals of the team. People will obviously be in a better position to accomplish their tasks in time if they feel "tuned" and actively participating in the definition of the results to achieve. Co-ordination of projects will then be much easier, and hopefully based on active support of the participants.

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Case 2: Organizational Network Responding to an Earthquake

In early 1998 an immense earthquake devastated an area in northern Afghanistan. As more than 2200 persons were killed and more than 8000 injured, the disaster created an enormous challenge for the humanitarian actions to provide relief. A number of local authorities, member organizations of the Red Cross and United Nations plus a number of smaller NGOs became active in the concerned area with the purpose of averting threats to life and death, especially due to the rigors of winter. Fighting the first and most important emergencies was managed within a month with the first relief organizations arriving one day after the disaster had become public.

This collaborative venture, however, had to overcome a few obstacles before delivering the necessary relief. Expectations and abilities of the relief organizations constantly interfered. As a result, it took a few days of precious time until a joint effort provided the essential support. More specifically, the whole venture suffered from the following shortcomings:

After earthquakes, it is especially the first days that determine the success of the intervention, because circumstances require immediate actions for injured people, the prevention of diseases etc, Whilst this phase is immensely important, the initial phase is also often turbulent and unpredictable. Due to the uncertain conditions the organizations have to expect, none of them is sure about the conditions one can expect. In this particular case, help had to be given to victims in a remote area that was difficult to access. The possibilities to rely on existing communication and transport systems were almost not existing and as the cold set in, the climate was an obstacle. In addition to these obstacles, collaboration was hindered by the organizations themselves. Due to their similar goals, many of the involved organizations are competitors in real life, competing for the funds dedicated to humanitarian issues. The inequality of the partners, their differing expectations, commitment, expertise and willingness to cooperate seriously affected the first phase of the project. No commonly elaborated plan existed, no partition of tasks was agreed upon, leading to uncertainties and conflicts about tasks and roles. Consequently, the level of trust among the organizations was low, making it difficult to easily make decisions and ensure their execution for the sake of the victims.

Even though this first phase was often frustrating and full of tensions, it turned out that the development of the network's efficiency improved significantly afterwards. The intensity of collaboration increased significantly. Once each partner had found its role, the processes proved to be very effective. Smaller organizations, for instance, often acted as the interfaces for big organizations which had the necessary logistics competencies. They were also able to fill the gaps in the large organizations' 'areas of indifference' and could thereby exploit their special competencies. One could even observe sub-networks emerging, uniting members of different organizations that creatively exchanged resources. Being asked about the intensity of conflicts during the first phase, respondents admitted tensions were severe, but arguments were mostly resolved on a fair level. Finally the willingness to cooperate outweighed the coordination shortcomings and the network showed the ability to work efficiently without having a central planning unit.

Collaborative facets

This special case demonstrates how networks can form when being under time pressure responding to very urgent problems. A strong cohesion due to shared values facilitated early solution-finding, especially in the light of the extreme circumstances. However, it seems there is still room for improving the collaborative behavior for disaster recovery actions. For sure, tensions between participants eventually had a positive effect. By negotiation, participants learned about their roles and the intentions and capabilities of others, but learning takes precious time.

Similar situations would occur in other disaster relief operations when effective emergency response management is needed.

Challenges

Especially in such a case it seems necessary to accelerate the collaboration.

- What if a global framework for recovery plans had been in existence and had been visible to all organizations aiming at playing a role in the recovery process?
- What if the large organizations had offered and promoted the possibility to connect to their organization cells and to their competencies?
- What if there had been widely accepted decision-making procedures in advance to speed up critical decisions?
- What if there had been a common infrastructure to enable collaboration from a technical point of view, so that there was a common infrastructure, that each partner disposed of a common set of communication devices etc.?
- What if there were appropriate "electronic institutions" to help in conflict resolution?

Based on a case study by the Natural Hazards Research and Applications Information Center and the Institute of Behavioral Science, University of Colorado, written by Aldo B. Benini

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Case 3: John Smith – The Portfolio Career

John Smith is a consultant working in the field of organisational development. For, 10 years he was employed as a Human Resource Development (HRD) professional culminating in a position of departmental manager for a global corporation in the telecommunications sector. His company, one of the few global "full service" providers in the world, hit hard times and was forced to shed 60% of its staff worldwide, over an 18 month period. John was one of the unlucky ones to be forced into redundancy.

His company decided to outsource the HRD function and agreed to offer John temporary, short term contracts, on an associate basis, when and where the need arose, if he was interested. At the age of 45, John knew that finding another similar permanent position would prove difficult, and so he decided to develop a network of associates to service the contract. But he needed to develop other lines of business to make his proposition viable.

He decided to approach a number of business schools, offering his services as an Associate Professor in Change Management. Two schools responded positively, one of which asked him to organise and manage an Affiliate faculty of visiting professors.

In his first year, John also managed to secure some work developing training tools for a large publishing house which specialised in developing multi-media content for "off-the-shelf training programmes. The contract involved coordinating the development of a series of publications on selected topics relevant to the business issues of the day. John was paid a fee according to the quantity of generic, output plus a premium for coordinating input from various key thinkers in the field in question. He would also derive some return in royalties depending on how many of each publication was sold. A key task in this project was to look for appropriate, contributors who would provide comment on his generic output so each publication would be seen by the market as having a sufficient level of credibility to promote the sale of each publication in the marketplace.

The rest of his time was divided between generating ideas and developing proposals which John believed would yield return in the long run as well as pursuing specific interests which were of particular interest to him. He classed these as ancillary interests and logged them in his accounts as such.

His ancillary interests included developing activities in areas where he felt his talents would benefit others on a range of "pet" projects. For example, John was deeply concerned about the fact that certain individuals in society were facing exclusion from the benefits to be derived from technological advance because they did not have a sufficient level of skill to enable them to contribute effectively. Such projects, although, personally fulfilling, did not prove financially rewarding. Nevertheless, so long as costs were covered, John was prepared to invest time and energy as part of his contribution to the development of caring society which he was keen to promote.

Collaborative facets

Contract with previous employer. The company had an existing contract with an established consultancy and John was contracted to manage the organisational development interventions. John was in the UK and corporate headquarters were in Paris. The rest of the team was located in the south of France. After meetings to decide the initial program design which were held in Brussels, John had periodic contact with his colleagues, mostly in the month before each residential course was to be held.
Contract with business schools. The contract required John to attend 4 Affiliate faculty meetings per year which he tried to coincide with his teaching and coaching commitments in order to keep within the travel budget he had been allocated. Scheduling was a problem as was the fact that the people with whom he was working were different in each case.
Publications. His plan was to publish one book per year and he had an initial agreement was for 4 books, each one on a different topic which he had to identify and define in consultation with relevant sponsors. Finding the contributors was a difficult and risky task which required considerable effort in business development.
Ancillary activities. It was difficult to decide on how much time to devote to "pet projects". At times the commitment required to do justice to those John considered as clients was considerable.

Challenges

Independence – John has a great deal of freedom in choosing what he wants to do. He is his own boss. Whether he succeeds or not is entirely down to his own efforts. He also has the freedom to balance his interests in a way that suits him best.
Entrepreneurial – John is forced to rely on his business acumen to achieve success. He must be creative in what he does and how he goes about generating business.
Variety – John derives his income from a wide variety of activities. Sometimes such activities may seem unrelated but the factor in common is John's interest. So John must be able to switch his focus and concentration from one project to another at a moments notice.
Location – John is not bound by any particular location. He has a portable PC which he carries with him everywhere. Wherever he is, that is where his office is located. Meetings are usually held at the clients' premises and if he needs a dedicated meeting room, he rents the space when required.
Communication – John communicates almost exclusively via email. He also uses a mobile phone which he finds much more convenient than a fixed line since he is on the move all the time.
Teamwork – With a variety of projects up and running, John works with a large number of people, with each project team comprising different sets of people. These teams are spread over a wide area and involve people from a variety of backgrounds and disciplines.

… but now John is wondering if he could get some tools on his PC that help him manage his complex, multi-context life....

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Case 4: Time Bank

The **Time Bank** concept provides a mechanism for collaborative community building / re-enforcement, i.e. a way for people to come together and help each other.

The idea is very simple: people "deposit" time they are willing to contribute to the community by giving practical help and support; in exchange they are able to "withdraw" their time when they need something done to themselves by others.

One key principle here is that one hour is equal to everybody. One hour of helping out with gardening is equal to an hour of legal advice.

So what can be "exchanged" in this way? From existing cases a large number of examples can be found, including: child care, breastfeeding support, children's activities, computer set-up, concrete/masonry, carpentry, plumbing, electrical, cooking, delivered meals, meal planning, first aid classes, massage, nursing assistant, nutritional counseling, tutoring, gardening services, phone companionship, bedside companionship, saying prayers, hairstyling, office help, house-cleaning, translating, …

The "**bank**" is some form of organization that takes care of registering members and implementing some bookkeeping mechanisms. Most of the existing cases run in a quasi ad-hoc manner, usually associated to the city hall or any charity organization, and mainly resorting to telephone and some complementary "get together" meetings. This "institution" also requires an administrator or broker that acts as the driving force (catalyst) of the community,

How does it work?

Let's suppose you would like some help -- maybe two hours' help in the garden. You contact the Time Bank and let them know what kind of help you will need, and when.

The Time Bank administrator (or broker) checks the members' records for a "match." The coordinator calls the match, then calls you back to confirm.

At the time you need, your Time Bank friend comes by and helps in the garden. Two hours help means two credits spent. You sign a form (check) for two credits. The person who helped you hands in the form to the administrator, who logs the exchange in the Time Bank's records. That person now has two credits to spend!

Some day later on, you might get a call from the Time Bank administrator asking you: would YOU like to help someone else and earn some time credits?

The Time Bank idea was originated in the USA in mid-80s by Edgar Cahn, motivated by the need not to feel useless, as he stated: "I did not like feeling useless ... in the 1980's society was declaring a lot of people useless, the unemployed, the elderly and the young". Then he came up with the idea "why not reward decency and caring?"

His initiative turned into a "movement" that has gained rapid acceptance not only in the USA, but also in various other countries.

One special case is a Time Bank for elderly support.

Collaborative facets

The Time Bank concept represents one special form of virtual community regulated by a few "core values" foundation:

- EQUALITY – It uses a "currency" (time) that is equal for everybody.
- CAN DO – It values people's contributions and recognizes that everyone has something to offer. Everyone has strengths and assets.
- SOCIAL (virtual) CAPITAL – A time bank links people and organizations for mutual advantage. It provides a way for people to support themselves, each other and their communities.
- RECIPROCITY – Everyone is a giver and a receiver. It is a two way street, not a one-way street.

Challenges

The organization and operation of a time bank community could be much facilitated if a proper ICT infrastructure and support tools are available. Some of the challenges here are:

- Brokering and match-making support. The lack of common ontology of activities / skills often represents an obstacle for both "givers" and "receivers".
- Negotiation and coordination mechanisms. Checking availability of "givers", negotiating conditions (e.g. date) are complementary to the match-making process.
- Members profiling. Proper characterization of members in terms of their skills and needs is necessary. This requires human intervention to explain the rules and possibilities.
- Credit system. Existing time bank communities have specific rules on how to collect and spend credits, but more generic principles can be implemented with ICT support.
- Accreditation and assessment. This is related to trust and evaluation of performance. Mechanisms are needed to identify members, provide feedback on how they performed, etc.
- Peer-to-peer interactions support. The time bank coordinator is a promoter but peer-to-peer interactions are encouraged (also because of the not-for-profit nature of these organizations). Virtual community support tools shall then be integrated with the time bank infrastructure.
- Combination of "virtual" and "physical" community aspects. Time banks promote gatherings / meetings of members in order to reinforce the sense of belonging and trust. ICT tools can facilitate the process.
- Additional aspects. Once a minimal infrastructure is available, additional functions could be devised. For instance, data mining applied to historic data to help improving the match-making process.

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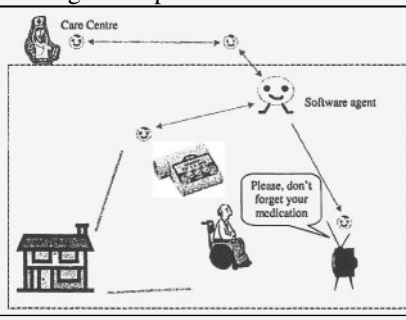
Case 5: Elderly care networks

Finding more effective ways of providing care to a growing number of elderly became a major challenge in Europe. In fact during the last three decades, the number of people aged from 60 years or more has risen about 50%. Today, more than 25% of Europe's population is aged 60 years or more and this trend will continue. Within 20 years approximately a third of Europe's population will be over 60 years old, a total in excess of 100 million citizens. These trends present a real challenge for the social policies in the years ahead and underline the importance of developing new and more cost-effective ways of and facilities providing care and support to the elderly.

Ideally, elderly would prefer to stay at home instead of being confined to a care center, provided that continuous and tuned to their needs care is available. Imagine therefore elderly persons living an independent lifestyle, in their homes, but "linked" to their relatives and to care providers via a computer network and computer-connected home appliances and sensors which relay information on their living status. To support this scenario integrated elderly care system comprises a number of organizations such as social security institutions, care centers / day centers, health care institutions, etc. and involves the cooperation of a number of different human actors e.g. social care assistants, health care professionals, the elderly people and their relatives. If supported by computer networks and adequate supporting tools such systems may evolve towards operating as a long-term virtual organization and the various involved actors become part of a virtual community (VC).

The following episodes illustrate the use of advanced technology, i.e. combination of computer networks, multi-agent systems, and remotely operated devices, in providing a new pervasive care environment.

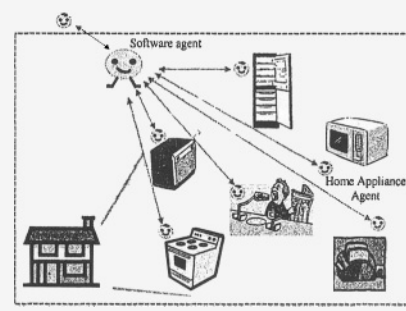


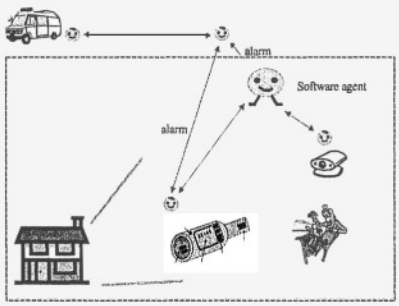
In the morning (wake up)

- There is an assistant agent who reminds Mr. Smith about the daily medication, and other possible actions: e.g., put the sensor wristband; Use the Spiro meter to check his vital signs, etc.
- Monitor agent sends detailed health-data of Mr. Smith to the ALFA-team Care Center and a summary to his daughter Mary.

At noon (lunch time)

- An agent controls the microwave to warm up the lunch (that was left there in the morning by Mary), or
- An agent that carries a plan, or instructions to prepare Mr. Smith's lunch, arrives at the elderly's home.
- Also, in an ideal situation, an agent checks the content of the fridge, and other places, like pantry, and sends this information to the Care Center and to Mary, or use this information to prepare the lunch by itself using robotized home appliances.





When there is an emergency

- A sensor agent (in the wristband) informs a supervisor agent about an anomaly, and sends an alarm to both the ALFA-team Care Center and to Mary.
- Another agent tries to verify the alarm, activating other agents (e.g., camera agent) and , determines the seriousness of the situation (issue reconfirmation information).
- In case of a serious situation, the supervisor agent sends an alarm and data/information of the vital signals of Mr. Smith directly to the ALFA-team Health Center.

Collaborative facets

This example scenario combines different perspectives of collaborative networks:

- Virtual organizations, as a number of public and private organizations can be involved in the collaborative care process.
- Virtual communities, involving care workers, the elderly and their relatives.
- Remote operation of sensors and devices, which is similar to issues tackled in virtual laboratories.
- Extensive use of ubiquitous (pervasive) computing.

Challenges

Some of the key challenges posed by this case include:

- High reliability of the infrastructures and services (continuous / permanent service availability is required).
- High levels of security to cope with the privacy requirements.
- Specialized user interfaces and "invisibility" of infrastructures.
- New paradigms of virtual communities providing "social involvement" of elderly.
- New mechanisms and concepts to make use of the accumulated knowledge and experience of elderly (active aging concept).
- Wider acceptance of standards for pervasive computing and related devices.

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Case 6: Women's NGO federation

Nowadays there are several non-governmental organizations (NGOs), devoted to defend women's rights and promote their participation in society. Examples include associations of "women in sports", "women teachers", "working women", etc.

Most of these organizations have a regional or national boundary. With the ongoing European integration process, many organizations start to interact with their "sister" organizations in the other countries.

When supported by Internet, one of the normal activities of these NGOs is the operation of a virtual community.

One of the key activities of such organizations is to react to or give advice regarding new legislative initiatives issued by governments. In this case, there is a need to quickly form a "mission team" (a small sub-set of members, either the most active and/or the most skilled regarding the topic under discussion) in order to prepare a reaction / recommendation. Given the short time of the "public consultation" processes and the natural inertia of these (voluntary) prganizations, a critical factor for success is the capability to rapidly form such mission teams.

The activity of the mission team, whose numbers are not co-located, requires proper support tools, e.g. discussion forum, chat, joint edition of documents.

The problem gets worse when the source of most regulations is moving from national level to the EU level. This requires the capability to rapidly organize multi-national teams. Furthermore, very often the regulations affect / relate to more than one focused NGO. In order to be effective (i.e. have more influence power), these NGOs feel the need to create a federation that, while allowing them to keep their individual focus, facilitates rapid joint intervention.

One difficulty here is of a legal nature. Very often, in order to be recognized as a valid interlocutor, governs require them to be a legal entity (not only a virtual federation). There are, therefore, issues of a proper legal framework to be solved and organizational models.

Another important issue in the federation process is the need to define mechanisms for handling the intellectual property. In fact, although they are "not for profit" organizations (in an economic sense), each NGO wants to have its contribution to, any joint mission properly recognized (issue of credit assignment). This recognition is also a mechanism to attract more members and get more influence power.

Collaborative facets

This scenario shares several aspects with breeding environments, virtual organizations, and virtual communities. The members of a NGO can be seen as a breeding environment out of which dynamic mission teams (like dynamic virtual organizations) can be formed when a need is identified (similarly to when a business opportunity is identified in a breeding environment).

The cooperation among different NGOs introduces a new level of complexity that can be modeled as a federation of breeding environments. The mission teams are then recruited from the federation, although taking into account some principles of representation. All NGOs want to be represented or might delegate their representation to other NGOs. Therefore, team formation mechanisms and support tools need to consider not only the effectiveness of the mission team (size, skills, etc.) but also the "representation" aspects.

The need to handle the intellectual property, although not involving monetary value, implies a "value system" that needs to be supported by the collaborative infrastructure and operating rules.

Challenges

Some of the challenges raised by this cooperation scenario include:

- Legal frameworks in order to ensure "acceptance" of federations of NGOs.
- Combination of breeding environment, virtual organization, and professional virtual community facets and support infrastructures (federation of NGOs, formation of mission teams, and collaboration among members that are human beings).
- Need for light infrastructures (not-for-profit organizations, without skilled ICT people).
- Handling IPR and "social recognition" in the case of federations.
- Development of electronic voting mechanisms to ensure the widest participation of the NGO members.
- New tools for dynamic and fast mission team formation.

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Case 7: e-Science - DNA Micro-Array Experiments

Consider the scenario where a biologist at a pharmaceutical company is working on a new drug. Let us assume that this drug is targeting a specific disease, for which the responsible gene is already known. The biologist wants to test whether the new drug is indeed preventing the activities of the target gene and under which conditions (e.g. under which concentration of the active materials the drug performs more efficiently). In order to investigate the activities of the target gene, the biologist needs to make a micro-array experiment.

The DNA micro-array device allows genome-wide monitoring of changes in gene expression levels, in response to some stimuli, for instance the expression of a gene in response to a certain drug. With the current advanced technology of DNA micro-arrays, it is possible to study the characteristics of thousands of genes within a single experiment.

To perform this complex study, the biologist at the pharmaceutical company must first designs a micro-array experiment. In general, the steps in a micro-array experiment can be grouped into five major tasks: clone preparation; micro-array production; DNA-probe preparation; hybridization, scanning and image analysis; and finally analysis of the results. At the last stage of the experiment, in order to see whether the developed drug indeed prevented the activities of the gene under the study or not, the biologist must analyze the experiment results. In this example, the biologist will cluster the expression results, in order to compare the target gene expression against the expression values of other known genes with similar activities. This comparison can also be extended to cover the results of the previous micro-array experiments. Please notice that depending on the available information about the drug and target gene, several micro-array experiments may be required to be performed, each using samples treated with the drug under certain specific conditions. In that case, information about all experiments has to be grouped to indicate the relation among them, and the analysis of the experiment results may include the usage of many software packages in combination, such as self-organizing maps for hierarchical clustering, or Pearson algorithm for statistical analysis. The analysis will require among others the utilization of high computational power, high-speed networks, storage facilities, and a variety of data analysis, simulation, and visualization tools. Only after the visualization and comparison of different kinds of results at this point, the biologist can conclude whether the target gene was expressed or suppressed with this drug treatment.

In the past this entire experiment could have only been performed in those big industries that could afford it, as a full-fledged micro-array lab with spotter, scanner, slide processor, etc. is a quite expensive facility. It is now a common practice that institutes and companies share the laboratory facilities. Assuming that our pharmaceutical company does not have a micro-array facility in house, in order to develop the drug, it needs to cooperate with a university to access the micro-array lab, with a biotechnology company for the clones and information, and with a chemical compounds company for drug ingredients, etc. This cooperation will help the micro-array lab to improve the lab facilities, and support the biotechnology and chemical compounds companies to continue with their research to provide better products. It is clear that cooperation among the institutes and companies each providing a resource is beneficial for each participant in the cooperation.

Collaborative facets

This scenario includes elements that go beyond the typical case of a virtual organization. In fact it combines both inter-organization cooperation and a professional virtual community. Researchers belonging to different organizations are involved in the realization of a cooperative experiment.

This kind of scenario and other examples from e-Science that require a Virtual Laboratory concept can also involve the remote operation of some lab equipments.

In order to properly support cooperation among the partners, rules of cooperation must be defined and mechanisms to preserve the autonomy of the independent companies must be provided. For instance, the pharmaceutical company and the micro-array lab must negotiate to define how many experiments can the company make in a week, who will provide which biomaterial to be used in the experiments, whether technician support is required from the lab or scientists from the company will make the experiments, how will be the form of payments, and how the security of the biomaterial used and experimental information will be provided. The answers to all these issues must be well defined and a contract must be prepared, which will be the legal base for cooperation among the companies and the laboratories.

Challenges

This example presents some research challenges for collaborative networks:

- Integrated support for virtual organizations and professional virtual communities.
- Remote access to some lab equipments for collaborative realizations of experiments.
- Development of appropriate "business perspective" including intellectual property rights.
- Better understanding of cooperation processes in this context and modeling of scientific experiment processes.
- Development of robust error recovery mechanisms.
- Specialized tools for processing large amounts of experimental data and their visualization.
- New resource management mechanisms with proper access rights / visibility mechanisms.
- Provision of transparent access to physically distributed data and processes. There is in fact already a huge amount of scientific data generated from experiments conducted world-wide in many areas, e.g. biology, physics, medicine, astronomy, etc.

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Case 8: New types of games

Every evening several youngsters from different parts of the world have a virtual appointment in the cyberspace to do their newest most enjoyable activity: collaborative playing.

In these new generation of games collaboration is as much important as competition. Participants must create teams that should be able to answer the challenge created for that day by the game manager. The issued challenges are problems that can only be coped with team collaboration. The types of challenges or objectives are wide and cover different domains, from a typical army objective in which the goal is to conquer some military objective, to an economic objective such as managing a company.

The participants might form and join teams that will compete in solving the challenge, which are created according to their individual skills and preferences. The winning team collects the prize, which, in general, is a score of points to be then distributed among team members according to their individual performance during the game. The points earned by individual members are used to increase the individual score of each skill he/she has contributed to the team. In this way, the points shown by every participant in each skill is nothing else than a measure of its qualification in that skill.

Every day they are obsessed and eager to find out the challenge of the day, which it is posted including the reward points that can be earned by the winner or winners.

The better-qualified ones (those with better scores) have greater chances of being able to participate in the most powerful teams, which in turn have better chances to win the better-rewarded challenges.

After the challenges are issued, the participants have some time to create the teams. Although each individual participant is allowed to start a team, teams can only be accepted to participate if they achieve a minimum level of competence in the skills required to solve that challenge.

When the game starts, each member must focus on the challenge and should intensively collaborate with the others members to contribute to the goal of the team. The better the individual members play the better he/she will score at the end of the game.

These types of collaborative games will reshape forever these youngsters' personalities. They will be better used than ever to do collaborative work, which will reshape work organisation within companies. This generation will be much more open to participate in collaborative tasks than previous generations, and, above all, will do it in a natural way.

Collaborative facets

Virtual teams are set-up daily. A breeding environment is needed to accommodate game participants. This breeding environment, among other things validates the scores and skills offered by each participant. The breading environment is thus an institution that ensures the value system of the community. Only the participants belonging to the breading environment can participate in the teams because they are the ones whose skills and scores are recognised as valid by all the other members.

Fast and easy communication among the participants is very critical, because the game is played interactively.

What is really new in this type of games is not the fact that groups of dispersed players are collaborating to achieve a common objective, which is already a common practice, but rather the fact that collaboration is better structured and organised by a set of methods and tools that help the formation of teams and improve the collaboration among team members, which is needed when the challenge is being solved. It should be noted that collaboration tasks during the running of the games are already possible, however, in this new generation, this characteristic is extended.

Challenges

This case suggests a number of R&D challenges, including:

- Creating and managing the players' breading environment.
- Supporting the creation of dynamic virtual teams whose members are located in different geographical regions and whose skills also vary.
- Implementing the value system to ensure that the scores shown by each participant are valid and recognisable by all the other members.
- How to measure the individual performance of each team member.
- The classification of skills, which are fundamental for the process of team formation.
- Tools to help the interaction of members during the run of the game.

To make things more difficult, performance is assessed on a daily basis and at two different levels: The distribution of points among the winning team (s) and then the distribution of points within the team. It is not an easy task to define how well a member has worked, unless a clear parameter definition that characterises the performance of a participant is created.

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See also http://switch.sjsu.edu/v7n1/articles/cindy02.html

Case 9: Virtual institutes

The market for business education has become increasingly competitive over the last 15 years. Corporations, now more than ever, look to recruit future business leaders who have a balanced appreciation for the challenges they face in develpping markets. As a result, business schools, have to devise new and innovative curricula in otder to differentiate themselves from their competitors. Network technologies provide new means of coordination and delivery.

Better Business Institute (BBI) is a progressive school based in the North of England. Recently, together with partner business schools in Spain, France and the US, it launched a 2 year Masters programme in Global Business Administration. The aim was to address the shortage of strategic leadership talent available to corporations operating in global markets. A wide range of subjects were offered and the programme faculty comprised professors from all over, the world. A diverse mix of experience and cultural background was a unique selling point for the programme. All partner institutes involved agreed from the outset that the programme should strive to mirror the real world as much as possible both in the way courses were designed and delivered. In other words, students should be given practical exposure to the kind of challenges they would face when working in a global context. To meet this objective, the student body was divided into teams for every subject taken. Each team was required to complete a project in which they would have to apply course concepts. Each team comprised students from each of the partner institutes. In this respect, every team had to organise itself appropriately, taking account of the fact that team members were geographically dispersed.

One of the unique selling points of the programme was that the pedagogical approach was very much based on the concept of "learning by doing". Aside form the traditional course lectures and tutorials, core courses involved working through computer based simulations which were designed to put students in situations similar to those which they would find in the real world. Simulations often involved team working and were conducted in virtual space. The students were required to work through the simulations according to a pre-defined timetable. As with the course assignments, tutors and lecturers could monitor student progress by logging on and observing activity. Since course assessment was very much oriented toward participation, in situations where teams/individuals were observed as under-performing, those involved would be contacted and asked to explain.

Collaborative Facets

The programme was designed with the intention that students could be exposed to the experience of project work in a multi-cultural, global environment. As such, both students and faculty were required to work closely with a variety of people from different backgrounds, most of whom they had never, and would never meet. Success was as much determined by the ability to work in collaboration as it was by individual effort.

Challenges

Both students and faculty face complex challenges in this scenario for which innovative support tools are needed:

Students

- To coordinate geographically dispersed project teams.
- Perform with minimal supervision.
- Trust fellow students upon whose performance had a direct impact on individual success.
- Balance complex multi-projects simultaneously.
- Time management.

Faculty

- Monitoring performance at a distance.
- Maintaining motivational levels in virtual space.
- Time management.

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Case 10: Fieldwork Online Training: the Online Business

Two years ago, Fieldwork Education, a UK-based company providing training and consultancy to the education sector, decided that the training programmes they were running, many of which were delivered in person to institutions in the Middle East and Asia, could be effectively delivered online. Face to face programmes would still run but these would be supported and augmented by online materials, thus widening the reach of the company and increasing awareness and availability of their products and services.

Initially, the internet was used simply as a means of delivering the course content. However, it soon became clear that technology, and specifically the Internet, could facilitate much more than simply the presentation of course text. Key to the success of the business was the generation of online communities – connecting not only students with each other and with remote tutors but, significantly, providing an interactive development 'hub' where the various participants in developing and supporting the training materials could work together and in real time. The technology could enable the business to grow organically and to be genuinely collaborative.

There were some key issues facing the business at that time. It was becoming increasingly difficult to manage the principle business functions – developing materials, delivering courses, managing users – and these problems were compounded by geographical factors – the user base was global and consequently covered a number of time zones; the writers and tutors were also geographically dispersed, although mainly based in Europe, and relied entirely on a linear system of course development; the business demanded that the two core staff members had to travel regularly, and there were no tools for supporting the business or the users remotely. The answer lay in the development of a chain of self-supporting communities.

The Internet provided the mechanism for generating these communities. A software solution was developed to move the entire business online. First, a course development suite was delivered. This allows the various team members to work collaboratively and in real time on a particular course and to communicate with each other throughout the process. Not only does this generate an environment which encourages creativity, it also reduces the burden on the editor significantly. Plus there are many less errors made during the development cycle.

Also, all customer management issues are integrated into this system. Orders flow directly in, invoices are generated, users are monitored and managed. From a user perspective, linking students into interactive communities performs a number of functions. Primarily it addresses the issue of isolation related to taking online courses – by providing communications tools, students feel more involved in the course and the experience becomes more humanised. Communities are also self-supporting – they help each other sort out problems, even of a technical nature. Plus there are opportunities for cross-over between the student communities and the tutor/author communities – authors can monitor responses to their courses and updates can be made accordingly and possibilities for the development of new courses can be identified by monitoring the interaction between live students. In this way, the service is truly organic and collaborative.

Collaborative Aspects

By providing an environment for course development, continuous assessment and student evaluation, the process of developing and updating training materials is collaborative on a number of different levels. Primarily, the course exists at the virtual centre of the development environment – that is to say that any number of participants within the virtual (and temporary) development team for that particular course can contribute at any point and in real time. This is a significant development from the traditional linear method of writing/editing/proofing that is often used when preparing materials for publication. Additional team members can be added at any point, simply by attributing permissions and providing a username and password. Equally, team members can be removed as easily meaning that the development team is as fluid and organic as the course itself.

Furthermore, the end users, in this case the students, become part of this collaborative process. By developing communities, part of the function of which is to provide a forum for feedback and critique, the course materials are in a continuous state of development informed by the people who really matter. Again, this feedback is in real time and is part of the same development environment. Problems and issues can be addressed instantaneously.

This exchange also happens the other way – the community of writers and tutors can feed into the user communities, providing support, advice, prompting discussion and so on. And the users themselves begin to feel a part of something, unlike traditional models of distance learning which struggle to generate the experience of shared learning.

Challenges

There are a number of challenges this model presents:

- The business is entirely reliant on technology to function. What happens when either the technology, or the people operating the technology, fail?
- As the business is based online, it requires that every participant – writers; tutors; students – buys in to the technology. In particular, the course development process requires total buy-in from every participant or it begins to malfunction.
- The notion of customer support becomes difficult to manage and quantify – while communities are self-supporting, there still needs to be a place for people to turn should the community not provide the answer. It is difficult to know what the nature and scale of customer support needs to be with a business of this type.
- Trust and credibility are an inherent issue with anything online – there is a notion that something is worth less is it is online, even if you have to pay to access it. The experience has to be 'real'.
- Virtual learning is still a new paradigm and it requires a cultural shift to accept this form as valid and to appreciate what it has to offer. Face to face training may be seen as better, more effective, as having greater impact. This is a hurdle that needs to be overcome.

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Case 10: The Future Worker as a Member of Various Networked Organisations

We envisage a future unified Europe to be one common market of labour and competence, where European citizens can choose to work in every country and within any organisational environment they wish or need to. In such an environment, national or cultural diversities must no longer be an obstacle for allocating tasks to a certain worker. In contrast, future work enyironments must facilitate the exploitation of such cultural or national characteristics for the profit of the individual worker as well as for the co-operative undertakings she/he is involved in.

Many of those workers will be employed by a company either with a permanent or a limited contract, and will perform their work within the organisational context of this company. An increasing number of workers, however, will be self-employed, offering and exploiting their competence and workforce wherever it is most effective and profitable. The individual worker or her/his employee will be member of various business networks and co-operative enterprises, which define the collaborative undertakings the worker will be engaged in. Consequently, the individual will be a member of different, sometimes even overlapping networked organisations, and the related contractual and collaborative environments will essentially influence the organisational context of the individual's work.

It can be further assumed that the common market of labour and competence will be more dynamic as today, which means that an increasing number of employee's contracts will be task- or competence-oriented and limited to certain missions, responsibilities, or undertakings. That will require that the worker will have to continuously update and increase his/her competence, to advertise it on the market and to effectively exploit it for the work to be performed. Consequently, the future worker will have to be a member of various expert and information networks for the purpose of continuous learning and updating her/his competence, knowledge and skills. Additionally, access to networks of labour and competence markets is required for information about opportunities and advertising of work force.

In this challenging, competence, and task-oriented work environment, the categorical partition of a worker's time into leisure and working hours will be relaxed. The worker will want to perform her/his tasks whenever and wherever it is necessary or he/she feels motivated or best prepared to do so. Particularly while travelling or commuting or in emergency situations, the future worker must be able to participate in collaborative tasks or to access and make use of collaborative environments in a personalised and situation-dependent way.

As we observe a Europe-wide trend to increase the responsibility of the individual for its social welfare, the responsibilities for health care as well as precautions for pensions and unemployment will shift more and more from the employer to the employee. This is part of the individual's social context, as will be private obligations and responsibilities (family, debts, mortgage, etc.). This context will require the individual to be a member of social networks, which overlap or extend the individual's organisational networks and must be specifically handled with respect to the limitations of privacy and trust.

Collaborative facets

Multiple organisations and teams. The individual worker offers his competence and workforce to multiple organisations and, consequently, is involved in multiple teams in parallel.
Multiple contexts. The partnership in multiple teams generates multiple contexts that must be observed and handled during collaboration, including organisational, cultural, social contexts as well as individual/ private situation, schedules, plans and requirements.
Context-specific sharing of information and knowledge. The various contexts define the requirements and the rules of having access to multiple sources of data and derive context-specific information and knowledge from those data. Equally these contexts require the individual to provide information and knowledge within the framework of the various contexts in collaborative settings.
Context-specific sharing and coordination of collaborative tasks. The various contexts define the requirements and rules of participating and / or coordinating multiple collaborative tasks, including quality, performance, cost aspects.
Personalised competence handling and advertising. Multiple teams and contexts require task-/context-oriented up-to-date competence, which must be continuously updated from different sources, typically resulting in various virtual/ collaborative learning environments as well as in networking with labour and competence markets.
Personalised/ situation dependent collaborative work environments. Innovative workspaces must enable and handle collaborative work in various settings and situations, including (among various others) office, construction site, home, travel, commuting, emergency.
Privacy and trust. The individual social context is to be handled within the limitations of privacy and trust, particularly when overlapping with organisational networks.

Challenges

The many challenges in this scenario are outlined and categorised below.

- Cooperation in Networked Organisations: cooperation support integrated into the individual's workspace; life-cycle-support of distributed teams; collaborative decision making and conflict resolution; integration of knowledge management into cooperation; virtual team support.
- Supporting People in Cooperation: human task support in distributed collaborative systems; groupware and networked individuals; integrating virtual and physical workspaces; personalised/ situation dependent cooperation; human interaction.
- Context-awareness: definition and modelline of context; awareness to context; control over context awareness; enabling services.
- Infrastructures: flexibility, tailorabilitv. interoperability, scalability; access, accounting, billing, payment, security; mobile and wireless services resource sharing and process integration.

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Scenario based on contributions to the project COCONET IST-2001-37460;www.telin.nl/CSCW/coconet

3. CONCLUSIONS

The set of cases included in this chapter raise a large number of challenges in terms of modeling, infrastructures, support tools, and new organizational and legal frameworks. They serve, therefore, the purpose of providing "motivator examples" for the need of more advanced research on new collaborative forms.

At a first glance, the following cases and aspects can be observed:

- Team formation under extreme time pressure.
- Processes not a-priori defined but rather relying on human creativity.
- Shared values and conflicts arising from simultaneously seeking (public) recognition.
- Conflicting multi-pole leadership.
- Free-lancing extended to new dimensions of complexity, like participation in multiple organizations / multiple contexts.
- New value systems that need to be identified and characterized.
- New concept of collaborative tele-assistance.
- Extreme cases of privacy and security requirements (personal data or very sensitive organization data / resources).
- Networks of breeding environments.
- E-Science and virtual laboratories.
- Transparency and easy access to remote devices / equipment.
- Flexible resource management mechanisms with advanced access rights specification and enforcement.
- Dynamic performance measurement and assessment.
- Multi-cultural collaborative environments and motivation management.
- Communities with intense real-time feedback and critique mechanisms.
- Personal competence management.

One of the most common facets is that emerging collaborative networked organizations are more and more focused on people, people's roles and needs.

This set of cases also correspond to a wide diversity of application domains, which shows that CNOs shall not be considered a "property" of a particular domain but rather represents in itself the emergence of a new scientific discipline. As any new discipline, there is the need to establish its foundations, which in a first phase involves the proper adaptation and integration of contributions from a diversity of other disciplines.

This "cross-sector" characteristic of this emerging phenomenon also points to the huge need for educational / training programs, which should go hand-in-hand with the research activities.

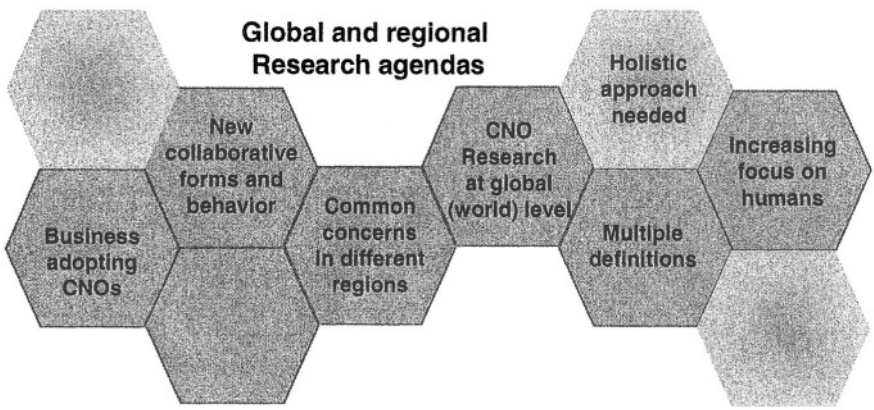
GLOBAL AND REGIONAL RESEARCH AGENDAS

OVERVIEW

The chapters presented in this part analyze the requirements of collaborative networked organizations, both from global and regional perspectives.

First the findings of a Delphi survey and a set of workshops held in different regions of Europe are summarized. In the first case a large panel of experts from industry and academia were invited to share their views on the perceived trends on CNOs and associated key drivers in organizational change. With the regional workshops a vast number of visionaries, from both industry and academia, contributed to the identification of major needs and research challenges.

In addition to these mostly European views, researchers from Japan, Australia, Brazil and the USA were also invited to contribute with a set of priorities for a research agenda on CNOs from the perspective of their geographical regions.



As a result the following key messages emerge:

- It is clear that businesses in various regions are rapidly adopting some forms of collaborative networks as a preferred method for facing the market turbulence challenges. Although most existing collaborative forms are

based on long-term relationships, some new collaborative forms and behaviors, not yet well understood, are emerging.

- CNOs face both technical and non-technical challenges spanning from a large number of disciplines, what calls for a holistic multi-disciplinary research approach.

- Although, the definition of virtual organization and other CNO forms vary from user to user, there are still a few predominant archetypes in terms of the most frequent collaboration practices.

- The role of human in collaborative organizations is becoming more and more a focus of attention. This raises important challenges not only in terms of understanding and supporting virtual communities, but also in terms of the mutual interactions and synergies between these communities and the networks of organizations, what opens the scope for further studies on social actors networks and the soft methods.

- Surprisingly enough, although some particular concerns can be identified in different specific regions, there is a vast core of common concerns expressed by visionaries from all geographic areas. There are however, different regional traditions and approaches regarding the way research is organized and planned.

- As globalization increases, future research on CNOs might yield a higher impact if it is undertaken at a global level; and even if that is not possible from administrative or political reasons, future research on CNOs can no longer focus on just a single region, rather it must take into account what is occurring in other regions.

TARGETING MAJOR NEW TRENDS

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The findings of a large Delphi survey designed to identify major trends in collaborative organizations are summarized. The survey was focused on a large number of drivers in the areas of technology, economy, environment and society, and law and politics. A total of 135 experts from industry and academia, in different regions of Europe, contributed to this survey.

1. INTRODUCTION

The Delphi method is one of the most well known methods to systematically collect and analyze experts' opinions when forecasting the future [1], [2]. This method is widely considered to be effective in situations where no hard data exist and the primary source of information is well informed, learned opinion from domain experts. The Delphi method was developed by the Rand Corporation for the U.S. Air Force in the late 1960s and typically obtains independent inputs from a group of individuals through an anonymous, iterative survey. THINK*creative* uses an adaptation of Delphi, combining the permanent core experts of the consortium with a large panel of experts gathered from different regions in Europe, as one of the instruments to identify major trends and likely future scenarios in collaborative forms.

The panel of respondents was formed by 135 experts from industry (69 %) and academia (31 %), from the following countries: Portugal, Germany, The Netherlands, UK, Switzerland, Belgium, Czech Republic, Slovakia, and Sweden. A few participants from Mexico and USA were also involved in the survey. Potential survey participants were identified using a number of mechanisms. Most of the participants were experts invited to a series of regional workshops held over Europe under the general topic "Towards collaborative relationships in the creative economy". Another group came from attendants of the PRO-VE'02 conference on Infrastructures for Virtual Enterprises, and finally various other experts from academia and industry were directly identified by the THINK*creative* members.

As a starting point, and based on a number of brainstorming sessions with THINKcreative experts, the following group of key variables or driving forces were identified as the driving forces to be analysed (Fig. 1).

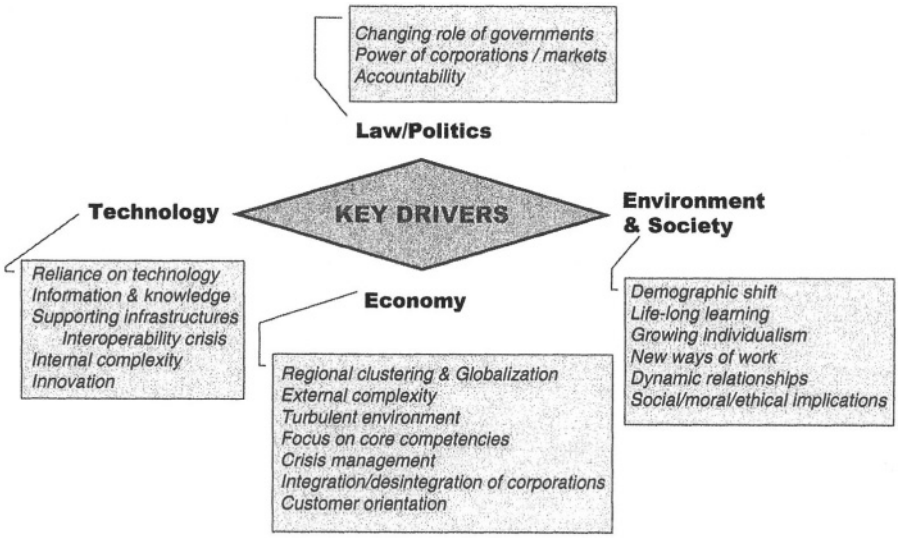

Figure 1. Key drivers in organizational changes

Economy:

- ***Regional clustering and Globalization –*** characterizing the relative roles of regional clustering forms in a context of growing globalization.
- ***External complexity*** – representing the way business processes are supported by collaborative complex networks.
- ***Turbulence environment*** – representing the rapid (dramatic) and hard to predict changes in the business environments.
- ***Focus on core competences*** – showing how much companies focus on a small number of core competencies in which they try to achieve world-level excellence.
- ***Crisis management*** – identifying whether the awareness and specific mechanisms to handle crisis management will become relevant.
- ***Integration vs. disintegration of corporations*** – representing the structural form of (large) corporations (monolithic organizations, networks of focused units), and the evolution of this form.
- ***Customer orientation*** – characterizing the trends in products and services regarding customer satisfaction and loyalty.

Environment and society:

- ***Demographic shift*** – identifying the consequences of the aging of population.
- ***Life-long learning –*** identifying the importance and awareness of life-long training and the reaction of traditional training provision organizations (e.g. universities).
- ***Growing individualism*** – measuring the relationships between individual needs, desires, and behavior, and collaborative relationships.
- ***New ways of work*** – measuring the relative proportion of the new ways of work (e.g. tele-work, e-free-lancing, individual entrepreneurship) versus "traditional" ways of work.

- ***Dynamic relationships*** – identifying whether the nature of collaborative organizational forms will be fundamentally dynamic, short-term based, or rather stable, long-term based.
- ***Social / moral / ethical implications of virtual collaborative environments*** – analyzing how the society, as a whole, will react to the new organizational forms and their social impacts.

***Law and Politics*:**

- ***Changing role of governments*** – identifying the changes of the government positioning regarding the business environment (business partner or business regulator).
- ***Power of corporations / markets*** – measuring the level of dominance that (large) corporations and markets have over the business environment.
- ***Accountability*** – measuring the level of accountability business organizations are called upon in terms of ethical, environment, financial, and social issues.

Technology:

- ***Reliance on technology*** – measuring how businesses and society in general will rely on technology or whether "human involvement" will be more considered.
- ***Information and knowledge*** – representing the impact of wide information and knowledge availability in the organizations behavior.
- ***Support infrastructure*** – measuring the level of adequacy / need for further developments on the supporting ICT technologies and infrastructures for new collaborative forms.
- ***Interoperability crisis*** – assessing the impacts of the software / hardware interoperability in the development of new forms of cooperation.
- ***Internal complexity*** – measuring both the complexity of the manufacturing and service provision systems, and the complexity of the product / services themselves.
- ***Innovation*** – measuring the importance of innovation on products, services and processes and its relationship to new collaborative organizational forms.

2. DELPHI FINDINGS

Based on the above variables, a Delphi process comprising 61 detailed questions was launched. The process is still going on in different regions of Europe, but based on the initial set of answers from 135 experts from all over Europe, the following preliminary findings can be observed.

As shown in the following table, there was no clear agreement among the respondents regarding some of the questions (e.g. the questions related to the roles of regional clustering versus globalization), at least for some of the periods. It also appears that, except in a few cases, respondents more easily agree on the forecast for medium (10 years) and long term (15 years) than for the short term (5 years).

Table 1 – Level of agreement among responses regarding major trends

	5 years	10 years	15 years
Regional clustering and Globalization			
Customer orientation			
Internal complexity			
External complexity			
Turbulence environment			
Focus on core competences			
Changing role of governments			
Power of corporations / markets			
Integration vs. disintegration of corporations			
Reliance on technology			
Accountability			
Information and knowledge			
Demographic shift			
Life-long learning			
Growing individualism			
New ways of work			
Dynamic relationships			
Innovation			
Social / moral / ethical implications			
Crisis management			
Support infrastructure			
Interoperability crisis			

Clear trend
Moderately clear trend
Unclear trend

Clear trend – when the distribution of answers on the variable is clear, meaning when either *most answers* are "agree" / "totally agree" or "disagree" / "totally disagree".

Moderately clear trend – when the distribution of most answers is either "agree" / "irrelevant" or "disagree" / "irrelevant".

Unclear trend– when the distribution of answers does not fall in the above two categories, i.e. when there is no clear agreement or disagreement among the experts.

An example of the Delphi questions and statistics of the answers is shown in Fig.2.

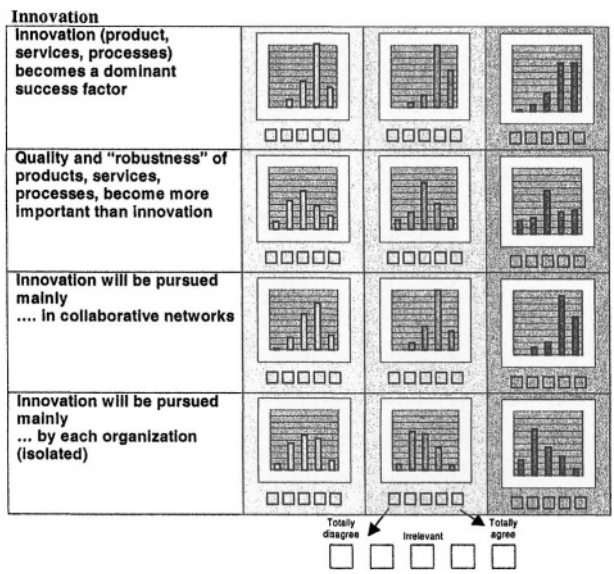
Innovation
Innovation (product, services, processes) becomes a dominant success factor
Quality and "robustness" of products, services, processes, become more important than innovation
Innovation will be pursued mainly .... in collaborative networks
Innovation will be pursued mainly ... by each organization (isolated)
Totally disagree
Irrelevant
Totally agree

Figure 2. Excerpt of the Delphi questionnaire and collected answers

From an analysis of the collected answers to the detailed questionnaire the following findings can be stated:

Regional clustering and Globalization

- Although regional clusters, by reinforcing long-term relationships and leveraging local "culture", local specificities, and proximity to customers, might have in the short term some effect against the threats of globalization, the trends in the medium and long term are unclear.

Customer orientation

- Trends in product / services, especially in medium and long term, point to mass customization.
- Guaranteeing customer loyalty is clearly a determining competitive advantage.
- The responsibility of customer satisfaction is likely to become more diluted among network members, and no so much and exclusive responsibility of the customer interface node.

Internal complexity

- Systems (e.g. manufacturing, service providers) will become increasingly complex, a trend that will become more clear in the medium and long term.
- There is a moderate tendency for products to become increasingly complex, namely in terms of their internal structure.

External complexity

- Business processes tend to be supported on highly dynamic and increasingly complex networks of collaborative entities, a trend particularly expected in the medium and long term, but not a so clear reality in the short term.

Turbulence environment

- The speed of change in business environments is likely to increase, even in the short term, and a definitive expectation for the long term.
- The amount of change in business environments is likely to continue growing, as a moderate expectation for the short term and a clear trend in the long term.

Focus on core competences

- In order to remain lean and highly efficient in competing markets, organizations progressively trend to focus on their core competencies.

Changing role of governments

- Governments will not be an active part in the business environment, but will progressively play only a regulatory role.

Power of corporations / markets

- Corporations / markets will increase power, reducing the power of governments and smaller organizations.

- The role of networks of small, agile organizations as a reaction to this scenario is unclear.

Integration vs. disintegration of corporations

- The structure of large organizations is likely to evolve, in the medium and long term, namely in the form of organized disintegration (forming complex networks of interacting units).

Reliance on technology

- Modern economy and society in general will increasingly rely on technology.
- In the medium and long term there will be a progressive emergence of a post-technology era with more emphasis put on the human skills.

Accountability

- There will be a growing accountability on ethical, environment, financial, and social issues.
- Although already a trend, this scenario will become clearer in the medium and long term.

Information and knowledge

- There is a clear expectation that organizations will more and more struggle with information and knowledge overload.
- At the same time, decision-making processes will be more based on a sound information and knowledge basis.

Demographic shift

- It is likely that the aging of population will accelerate the emergence of new-organizational forms in the medium and long term.
- But the aging of population will be progressively compensated by increased migration flows, which in turn might lead to an increase of socio-cultural clashes.

Life-long learning

- Life-long learning will become widely recognized and supported by organizations.
- In the medium and long term, as a reaction to the market demand, universities will change their teaching models in order to offer life-long learning programs.
- At the same time new curricula have to be defined by universities and training institutions, including new competencies that are fundamental to assure new organizational forms and ways of doing business.

Growing individualism

- There is an expectation that in the medium term and especially in the long term collaborative behavior and strong human networks (professional and social) will grow as a reaction to a competitive fast changing society.

- In parallel, also in the medium and long term, it is expectable that new social systems will emerge to provide for new contractual relationships between individuals and organizations.
- In the short term, under increasing competition and social turbulence, the social trends are unclear.

New ways of work

- In the short and medium term, new ways of work (e.g. tele-work, e-free-lancing, entrepreneurships) will stay confined to specific sectors.
- In the long term there is a moderate expectation that new ways of work will become more significant (20-55%).

Dynamic relationships

- In the medium and long term we might observe a growth in dynamic short-term collaborative relationships, especially within limited contexts (e.g. regional clusters).
- In the short terms it remains unclear whether the collaborative relationships will be established mainly on a long-term basis or on a short-term dynamic basis.

Innovation

- Innovation on products, services, and processes will clearly become a dominant success factor.
- Innovation will be pursued mainly in collaborative networks, especially in the medium and long term.

Social / moral / ethical implications of virtual collaborative environments

- It is not expectable that society will react against virtual collaborative environments (i.e. a push-back in technological development is not foreseen). On the contrary the society will progressively learn to make the best use of virtual collaborative environments and technology.

Crisis management

- There is a moderate expectation that, in the medium and long term, crisis management will become a standard "capability" in organizations.
- At the same time, crisis management might become a specialized activity (market niche) for some specific entities.

Support infrastructures

- In the short term current technologies could provide adequate support for agile / dynamic cooperative organizations but the lack of common infrastructures and business support functions is regarded as an obstacle.
- In the medium and long term the trends are unclear, which might be related to the uncertainty regarding the requirements posed by new organizational forms.

Interoperability crisis

- In the short and medium terms, the lack of interoperability of SW/HW

systems represents a crucial obstacle in developing new forms of cooperation. This obstacle is however attenuated by engineering efforts.

- In the long term, the interoperability scenario is unclear.

4. CONCLUSIONS

The Delphi method represents a reasonable way of organizing the process of collecting the views of a large number of experts regarding a set of selected drivers of future trends. Considering, however, the large scope of the topics addressed and the corresponding diversity of expertise of the involved panel of experts, we noticed that some participants had difficulties in understanding or expressing clear opinions on some topics. In some cases the questionnaires were distributed in the context of some THINKcreative workshops and panels and some clarification of the concepts and terminology could be made. However, in most cases, this was not possible.

Furthermore, it was surprisingly observed that a more clear convergence of opinions could be obtained when the time frame was the medium and long term. For the short term there was more dispersion of opinions, what is perhaps consequence of the "turbulence" currently observed in terms of business practices and technological evolution. The lack of a solid theoretical foundation in the area of collaborative networks also leads to a large number of misunderstandings and myths.

5. REFERENCES

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CHALLENGES OF COLLABORATIVE NETWORKS IN EUROPE

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*This chapter summarizes the results of a series of discussions, focused on emerging industry needs, held with the experts in the field, during twelve regional THINK*creative *workshops in Europe. The chapter further categorizes the discussed challenging requirements for industries, and draws some conclusions on these findings. The workshops were held in 2002/2003 in seven European countries, namely Portugal, UK, Czech Republic, The Netherlands, Germany, Belgium and Switzerland. In total, more than 400 participants, mostly from a wide range of Industry, and also some from the research and academia, attended these workshops. The presence of experts from research and academia facilitated some discussion on base concepts, and was necessary to better Inform industry experts of both the advances in the Virtual Organization paradigm and the advantages of its potential application to future emerging, competitive, and global market opportunities.*

1. INTRODUCTION

As a part of the THINKcreative project workplan and a key mechanism to get a large involvement of experts in this initiative from industry and academia was the organization of regional workshops in different regions of Europe. Twelve regional workshops were held in Portugal, UK, Czech Republic, The Netherlands, Germany, Belgium, and Switzerland. Through these regional workshops, it was possible to involve more than 400 expert participants that otherwise would not travel abroad to attend any event in one major European city. This is particularly true in the case of people coming from small and medium size enterprises (SMEs), which constitute the typical industrial landscape in Europe, while many SMEs were quite willing to participate in these local discussion meetings.

The regional workshops were devoted to the topic: "*Towards collaborative relationships in the Creative Economy*". Discussions were stimulated by the following three main questions [3]:

1. *Which inter-organization collaborative relationships will emerge (new forms) or will be further developed (current forms) within the next 5, 10, 15 years?*

2. *Which IT tools and functionalities have to be developed / improved in order to support those collaborative relationships?*
3. *Which socio-organizational, legal and ethical frameworks will result / or are needed to support the new collaborative relationships?*

This chapter summarizes the main findings of the discussions held in these workshops.

Due to the lack of a formal comprehensive definition for future collaborative organizations or Virtual Organizations (VOs), during the regional workshops in Europe, a prominent topic of discussion was the definition and better understanding of the VO paradigm and its main components. The widely accepted descriptions resulted from these discussions are summarized below:

- A virtual organization constitutes a number of cooperating independent organizations with certain common purposes that provide a set of services and functionalities to the outside world, as if together they represent one organization.
- In one of the alternative cases the configuration of cooperating organizations can change in time. Usually, the dynamism of VOs depends on the function/service to be provided at a given point in time, e.g. dynamic VOs are appropriate to design innovative products. In another alternative case, a virtual organization can have a more stable configuration, with a defined time span providing a stable set of services and functions.
- The coordination role in the VO is either played by one elected entity, or no single entity in the VO has the overall decision authority. In the later case, each decision has to be reached through a consensus at the end of a complex consultation process among different organizations involved in the VO.

There are still many open questions regarding the concept of virtualization for organizations. In principle, a virtual organization refers to changing the traditional view of doing business by a single enterprise, and provokes the development of (semi-)dynamic and flexible organizations for doing business. Better understanding and management of *changes* on many aspects such as the *customers'* needs, the service and *product* life cycles, the mutual relationships among the network partners etc., are the main principles for building this virtuality. Spontaneous changes and replacement of partners in dynamic virtual organizations is very often a necessity. Thus, requiring flexibility both in the organization and in the cooperation among the participating enterprises.

Due to the globalization of the economy, companies are forced to support reactive responses to the market changes, as well as producing high quality. These challenges affect in particular the SMEs that see a strong need in broadening their market boundaries in order to improve, remain competitive or to simply survive. In general, a SME does not have available resources, capacities and skills that are necessary to design, produce, sell and maintain competitive complex and innovative goods, or to provide highly sophisticated services in a broader market. For this reason, both the competitiveness as well as the ability to address new markets for SMEs are, and tend to remain, limited.

Bigger companies are continuously trying to reduce costs while achieving better quality. This fact directs their concentration on core activities. Outsourcing of the non-core activities have become an attractive option. There is however an important question remaining for each organization: What is the right level of granularity for

the tasks to be carried out by the organization itself and those to be outsourced? Is it the entire business process or just some of its elementary functions that should be assigned to other organizations?

Experts from industry and research seem to identify many of the challenges, gaps and weak points of the current VOs, but find it difficult to convey their visions of the future.

Two prominent situations were identified at the workshops as the main emerging reason stimulating enterprises towards the VO establishment:

- Efficient, highly distributed, and cooperative product manufacturing as well as distributed and cooperative service provision in more and more complex and dynamically changing environments.
- Survival of SMEs and increasing their competitiveness, either through flexible and highly dynamic cooperation among themselves, or among SMEs and larger dominating vendors/service providers.

The VO networks must enable the involved organizations to develop the capability of setting up their needed processes in reasonable time, in order to capture business opportunities, which no single company can do on its own.

2. TYPES OF VIRTUAL ORGANIZATIONS

As described in [1], a number of facets can be considered when classifying the wide variety of types of virtual organizations, including the duration, topology, coordination, participation, visibility levels, etc. However, in the regional workshops it was argued and was accepted that among all possible types of VOs, a few stand out as the most probable cases in the near future. Focusing on these few types helps to better identify the important needs and requirements of these VOs in supporting different disciplines. In principle, three distinguished basic types of virtual organizations were identified and discussed at the workshops as emerging and gaining more importance:

Type A) This type of VO is based on **a long-term partnership of SMEs with one dominant partner** (or a few dominant partners). The VO in this case helps organizing chains/networks of cooperating suppliers and/or sellers. The dominant partner in this (nearly) hierarchical network is the carrier of the business. Further, the dominant partner owns the core knowledge, trademark, logo etc., and plays a decisive role in defining the cooperation rules.

In a variation to type A of VOs, in the case where a long-term consortium does not yet exist, it is possible to rely on industry *clusters.* The credibility of the organizations, as specified within the cluster, can be used to choose the right partners for joining a VO, either for the project based VOs or for creating short term VOs, as categorized below. As such, the existence of "clusters" or breeding environments [2], indicating the credibility and background history of the participating organizations, is a definite a-priori condition for creation of dynamic VOs. Some new technologies such as the UDDI and WSDL addresses some approaches towards the creation / management of such clusters. More than the Type A, Types B and C for VOs defined below, represent two potential future cases both

based on the pre-requisite of clusters/breeding environments for the creation / configuration of dynamic VOs.

Type B) This type of VO is oriented towards **a dynamic *project-based* partnership**. Typically, such network of organizations **does not have a dominant element**; it is usually organized as a democracy, quasi-stable structure of bodies with complementary capabilities. The network relies mainly on experience with well-established partnerships. Negotiations, resulting widely acceptable consensus, represent the main principle of decision-making in this type of VOs. As a rule, one of the organizations represents the driving force behind each of the missions to be accomplished in the VO and plays the role of a "broker".

Type C) This type of VO is based on **temporary partnerships aimed by one organization to explore short-term market opportunities,** mostly among SMEs. Organizations in such a network, usually small SMEs operating in a limited area, join temporarily and very often occasionally, to meet a certain short-term goal. The cooperation rules inside the network are usually the public standard rules that are set-up by external bodies (e.g. governments, chambers of commerce, or by common traditions), there is no resource (and need) to fix these rules internally within such a VO. *Spontaneous cooperation* appears very often as the main cooperation principle. Some entities can play just the role of organizers/mediators without any other specific activity such as manufacturing or service providing tasks in the VO.

The categorization of the main kinds of VOs identified the main emerging organizational forms and the leading trends. There are also some VOs of a hybrid nature regarding this classification, where VOs are in a transition period in the case where one form of VO in time transforms into another, and do not fall precisely within any of the categories mentioned above. The diversity of forms is a significant and quite a natural feature of the VOs.

A number of new forms of collaboration are currently emerging particularly between the public and private sectors. It is becoming increasingly difficult to distinguish the difference between the organizations that collaborate in a structured way and a single organization, particularly when the structured collaboration is presented to the market by a single image.

The opinion expressed by the experts at the workshop represented that currently there are many organizational forms heading one way or another towards the VOs. Thus, it is timely to first research the evolution of these emerging organizational forms rather than to develop and impose radically "new" forms of organization for VOs. Also, strengthening and facilitating existing cooperative relationships through emerging standards was strongly recommended as the right way in assisting the development of support environments for the VOs.

Furthermore it is clear that future virtual organizational forms in every region will also be influenced by other criteria, such as changes in the surrounding environment, in legal and economical conditions, and in the ICT cooperation infrastructures developments, among others.

It is necessary to consider that there is a huge difference between aims of the most advanced cases of VOs, and the situation in majority of SMEs today! A risk was identified at the workshop, that the very complex advanced plans for VO initiatives might overlook the reality of SME limitations and not be applicable to

real cases. It was however discussed that a growing number of emerging best practice examples will gradually reduce this skepticism, particularly among the SMEs.

3. CHALLENGES TO BE TACKLED BY VOS

In order to respond to VO challenges, future research programs in advanced virtual organizations and new collaborative networked organizations shall in fact cover a wide spectrum of areas. Research initiatives must effectively combine and integrate contributions from multiple disciplines, namely the Computer Science, Management, Sociology and Organizational Sciences, while further receiving input and applying methodologies developed in other fields from Economy and Ecology to even Biology and Physics, but also taking other aspects such as Moral and Ethics into account.

More specifically, the main challenges and issues to be addressed by immediate research in VOs are of different nature [3], requiring innovative solutions from different disciplines. So far, the following disciplines and category of challenges are usually distinguished for VO research:

- organizational,
- technical/technological,
- legal, and
- socio-ethical.

Furthermore, the geography-related "regional versus global" issues must be carefully investigated.

In fact, a thought provoking commonly expressed opinion by industry experts indicate that today challenges for building successful VOs are 20% of technical nature while 80% being mostly of organizational nature and to a far smaller extent social, legal, and ethical, and otherwise. And, especially the lack of proper organizational - namely VO management – approaches, and gaps in the supporting legal system the main obstacles for having more successful cases of VOs in practice and not as much the technical challenges. Clearly enough, this topic provoked a lot of discussion among technical experts and others in several of the workshops. The main results of these discussions are summarized below.

It was discussed in several regional meetings that this expressed view of industry experts is partially due to a **myth,** which results from assuming that technical challenges are only technological based. This argument is further clarified below.

While the base *technological platform* required for the establishment of VOs is advanced, and may satisfy most requirements, when it comes to tackling *technical challenges* to support VOs, there are in fact three completely distinct aspects that require R&D innovation, each with different characteristics and applications to VOs:

1) Building horizontal base infrastructure for VO, e.g. federated information management and safe communication.
2) Formal modeling of VO and its dynamism and the definition and IT support for different VO behavior (e.g. coordination, supervision, and DBP management).

3) Vertical VO software tools must support life cycle related services, e.g. specific software tools assisting VO creation / operation / dissolution and decision support systems. Furthermore, software tools are also needed to support automation of VO-related functionality from other disciplines.

Sometimes one or more of these distinct aspects and strong requirements for VOs are overlooked by the industry experts or even by researchers of other areas. This is usually the main reason for this common myth that unresolved challenges in VOs are only 20% IT related.

The horizontal framework for VOs focuses on the hardware / software ICT aspects and on the identification and characterization of the required platform for the VO, and on building and provision of as much as possible a transparent and affordable base infrastructure, i.e. an "execution environment" for interoperability, information federation, and distributed business process execution, while preserving the required multi-level safety / security.

Formal modeling of dynamic collaborative network of enterprises is a base requirement to clearly understand the structure and behavior of VOs, in all its perspectives. Formal description of VOs requires strong interaction between the IT experts and the socio-ethical-organizational experts. The formal definition and modeling of VOs can however be usually better handled by the IT experts, due to their specific background in formal modeling approaches and methodologies. Further, a reference model for VOs and their architectures must be defined.

A number of specific vertical support software tools and decision support systems are required to be designed and developed for VOs. Thus support services must in fact provide as much as possible user-friendly, easy to use, and affordable software to assist with different aspects of the VO life cycle. These vertical components in fact shall go beyond the base IT aspects usually considered for VOs, and can cover provision of automated IT base support for VOs with functionality of different nature and for different disciplines involved in VOs, that requires further research, such as:

- Organizational issues
- Legal issues
- Social / ethical issues
- Regional vs. global issues
- etc.

The remaining of this section refers to the main challenges for each of the above specified disciplines.

3.1. Organizational and management challenges

Experts in Europe are of the opinion that so far no adequate methodology, approach, or principles are designed for the "management" of the emerging Virtual Organizations (VOs). For the top management there are no specific methodologies or tools at hand yet, namely the top managers must either learn in practice, either applying new trial and error techniques on the fly, or apply the approaches from their previous experiences in a single enterprise management.

New prominent and critical managerial issues pinpointed by the experts in Europe include: (1) the *monitoring* of the joint activities among people/partners

from different organizations, (2) how much information on the VO organization and at what *level of visibility* should it be available to every such team/partner, and (3) conflict resolution and making decisions on behalf of the VO. Furthermore, the complexity of managing a VO requires several managerial actions at the VO level (e.g. selection, hiring / firing of VO enterprise partners, etc.), that need to be assisted by some software tool and can no longer be simply performed over the phone or by e-mail. The side-effects of every managerial decision must be also carefully considered and handled. Development of new strategic approaches assisted by some IT based tools is required to identify the role and position of every partner in the VO, how to navigate and monitor the activities and make decisions in a cooperative network are among other important issues.

The brokerage function is seen as an essential ingredient to activate the virtual organization, and more development efforts are needed to develop automated tools that are required to increase the VO's brokerage performance. However, it is now becoming more and more evident that industrial VOs can only become a wide spread reality, if there is a so called "breeding environment" or "clusters" representing an established *club* of potential candidates for certain area of activity consisting a number of enterprises as members, where common pre-defined rules and infrastructure are adopted by all these members to serve as the base for creation and/or reconfiguration of VOs.

Through the entire life-cycle of the VO, the role and responsibilities of each partner, both inside the VOs and outside (if representing the VO to the outside world) must be clearly defined. It should be clarified who represents the VO in external relationships, e.g. marketing, contracting, selling, etc. There are currently many different models of responsibility distribution/sharing inside the VOs. In principle, two distinct approaches to this problem include: the approach that stresses the role of a central control unit versus the approach that suggests shared and distributed responsibility for all involved partners. A large number of problems also need to be dealt with concerning the VO termination. For instance, in manufacturing VOs, who will be responsible for the continuation of the maintenance support? Just one entity or all partners? This also touches the issue of VO *inheritance*.

There is a need for further research and more theoretical and experimental work to better understand the underlying mechanisms of VO cooperation and competition, and the underlying principles of self-organizing systems. Some work on learning webs can give some insight in this direction. Other related areas identified by the experts as requiring research include: understanding what can cause a turbulence in VOs, how to identify opportunities, and what are the required breeding environment conditions for innovation.

More theoretical work is also needed on understanding the roles and variety of approaches for leadership and coordination of VOs, the effects of VO's vision/mission on the individual organizations, and the emergence and establishment of coordination rules and "normative" institutions.

New methods and tools for "financing" larger VO-based projects and new product developments are needed to be developed. However, the banking sector is not prepared to provide this kind of services today, because standards for VO's risk assessment and liabilities are still missing. Mechanisms for risk assessment and risk management for VOs need to be developed in order to enable both the VO managers to identify, describe, and limit the risks associated with future VOs as well as for

other institutions to assess their own risk of potential involvement in the VOs. This single feature has proven to be a killer for many potential current collaborative initiatives.

3.2 Technical / technological challenges

As explained earlier, a large number of challenges of technical and technological nature were discussed at the regional meetings. First, the need for VO horizontal infrastructure including the lack of VO modeling issues were stressed and discussed. The research and development on a support platform for VOs shall focus on the study of VO requirements, reference models, methods, and architectures, as well as software components and tools to provide a base framework on top of which re-usable vertical services and configurable enablers for VO life-cycle-support can be developed.

The VO infrastructure design must be supported by formal and sound theoretical base. Furthermore, understanding and modeling the emerging behavior in new collaborative networked organizations is a key research challenge and pre-requisite for the design and development of new *support infrastructures*. Also the concept of "emergence" itself and the balance of emergent vs. deliberative strategies for modeling the VO behavior need to be better understood in this context. However, considering that not a single formalism/theory is enough to represent/capture all aspects of the emerging organizational forms and behavior, a first step for development of proper technical support of VOs includes exploring the theories and formalisms from different areas.

Various theories of complexity provide some insight on how to approach the analysis of new organizational forms and their emerging behavior. But, we cannot simply adopt models that for instance are developed in scientific areas of physics and biology, since the human aspect of the VOs plays a prominent role in the total behavior of the emerging collaborative networks and the "human-social" elements are difficult to model. However, still the methodologies and basic principles researched in the area of "complexity" represent a promising starting point.

On the other hand for the current level of collaborations among organizations, with limited benefit from Information and Communication Technologies, involved in industrial applications, the provided ICT seems sufficient. In fact, at present it even appears that existing tools provide more functionality than the users request. Most companies (SMEs) do not even regularly use simple software tools for any collaborative work. Some existing IT infrastructures, that are typically huge and expensive software systems, are used for certain collaboration activities within the large companies. Such systems are usually applied to support some distributed project management or network coordination. Due to the lack of other user friendly and inexpensive IT developments, so far only the application of the standard e-mailing and some use of simple web-portals for virtual community management are considered by SMEs, and have been sufficient for the requirements of the present simple VOs.

But the reality of emerging VOs is different. The need for easy to use and affordable tools is rising fast. This is the minimum requirement to help SMEs start using IT tools, and to move from their traditional facilities (e.g. fax, phone) to the IT environment.

It has become clear that in order to support future requirements, the current software tools are either too limited or too large and expensive. It would be for instance necessary and desirable to create better e-marketplaces to link SMEs together. High level requirements for future IT tools and support functionalities for VOs include network centric solutions, cross-platform interoperability, platform-independent software tools, and tools for efficient integration of legacy systems. Furthermore, the wide spread usage of these tools requires that they are easy to use, transparent, and affordable.

The remaining of this section briefly addresses a number of promising areas of research that were identified at some regional workshops as necessary to provide the required technical support for emerging VOs. One potential suitable paradigm to be considered for representing the network centric technology is the agent-based solutions and theory of multi-agent systems. Software tools based on the multi-agent approach should be very modular, and with standardized interfaces, communication protocols, knowledge ontologies and negotiation protocols. Standardization in the field of agent technology is well managed by the FIPA (Foundation for Intelligent Physical Agents) consortium. Standardized tools for automatic negotiations, bidding, contracting, etc. are crucial for speeding-up all the processes connected with the VO life cycle. The VO community has not yet explored the multi-agent theory in the extent needed (and possible). Leveraging of multi-agent approach and adopting it to support the VO requirements seems promising. An agent based standard methodology supporting a unified model of processes in the VO seems plausible and must be further studied.

Clearly, the technical backbone components of the infrastructure must be completely hidden from users through user-friendly interfaces.

A common serious bottleneck for creating and operating the VOs stems from the lack of proper interaction / interoperability means / platform among involved partners. Standardization in the networked interaction environment represents one main critical necessity. However, unfortunately, so far not much progress is achieved in this direction. Many proposed solutions are only simplistic approaches, such as the use of XML, that can at best only support the exchange of information among the enterprises at the syntactic level. This is not at all enough to tackle the complexity of collaborative relationships among enterprises. There is even this danger that the current over-simplification of the tools distracts the development of necessary and powerful functionality, and thus in the long term disappoint the users and damage the potential of VOs in industrial practice. Efficient support of the standardization efforts, and investments in development of the VO infrastructure, and interaction / collaboration platform, by national and international organizations would be highly required and timely.

Further to standardization and interoperation, there is an urgent need to design better approaches and algorithms in several areas including distributed business process, distributed task coordination, information federation / integration, and simulation as a backbone for extended common collaboration tools. These would support the management of business processes that define relationships and task sharing among enterprises. Significant move from transactional information exchanges to forecast/planning information exchange should be achieved. Thus, the distributed planning, monitoring, coordination, and simulation represent other important research topics.

Knowledge / data represents a very important element in VOs. Among other advantages, the VOs are created to help sharing highly specialized knowledge and expertise among its partners. Both knowledge sharing and knowledge transfer processes will be crucial for flexibility and reliability of the network as a whole, and it is necessary to consider that substantial part of the knowledge is unstructured. At the same time, certain parts of the knowledge should be kept private since besides the need to support the autonomy of each partner, one partner can even participate in two or more independent or competing VOs. Federated information management and the architecture of knowledge structures seem to be suitable for handling the necessary level of information visibility and access rights efficiently. Knowledge-based approaches are also certainly required but the emphasis has to be put on soft modeling (incomplete/uncertain/imprecise knowledge), multi-level modeling, and on capturing the socio-cultural dynamics.

There is a lack of good workflow support, and activity coordination and management systems, to handle the increasing need for distributed cooperative activities in VOs. The lack of standards for representing and modeling of distributed business processes is a major obstacle for the coordination and execution of distributed VO tasks

However, as explained earlier in section 3, please notice that in addition to the technical issues described, the study of every other area and discipline involved in VO will open a new set of required support for VO functionalities, and thus require many new IT related systems, tools, and perhaps even some added functionality to the base infrastructures. For example, in manufacturing VOs, self-identification of products, allowing traceability and closing the gap between the physical world and the logical information space, becomes more and more important, specially if the product is developed within a VO, where tracing the history and responsibilities among its partners become extremely important. The AUTO-ID initiative represents a good step in this direction. Similar innovative approaches must be developed for service-oriented VOs.

These and many other areas were discussed at different workshops as the main areas that need to be researched for proper support of VOs.

At the same time, education and training of IT specialists for VO support and development was also identified as a very critical aspect. There will be continuous shortage of IT experts in coming years. Lack of IT specialists might cause serious difficulties in running the VO businesses, wider support to VO-based IT education/research at both graduate and undergraduate levels need to be supported by European governments.

3.3. Legal challenges

There are many legal challenges to be tackled and legal questions to be answered in the VO paradigm. For instance, questions to be answered include how far is it necessary for the VO to proceed with the creation of a “real” new VO identity with its logo, brand name, etc.? What is the degree of legal independence of individual partners? How to save the past and future investments of individual partners? How to handle the responsibility towards the “external world” (central versus shared responsibility)? How to define the owner of VO results and its IPR?

Majority of the currently existing networked organizations are simply based on: personal trust relationships, and the informal sharing of the knowledge, opportunities, intellectual properties, profit, and losses. In future larger and geographically dispersed VOs, all the above aspects must be embodied in more formal frameworks, also protecting the minor players in the VO. Otherwise, there is a danger that the dominant partner(s) or the dominant knowledge owner(s) in the VO could achieve uncontrolled power over the VO and taking all the profit that otherwise must be shared among partners. Suitable legal frameworks are required for VOs of future and currently missing; the current legal environment does not provide any guarantee for the entrepreneurship and SMEs in the area of VOs, as it has been tailored mainly supporting the needs of single big enterprise and certain specific kinds of bi-lateral agreements for outsourcing between larger, well-established companies with SMEs.

In specific, the issues of intellectual property rights, knowledge ownership, and VO control, if not properly understood, well-defined, and supported by law, will significantly limit the development of collaborative networks.

Furthermore, many legal problems may come up in connection with liability, maintenance, etc. of VO results, being product, services, or innovations, that certainly become even a bigger problem after the VO termination. VO related regulations should also address and embed the VO termination. In other words, a VO cannot sell a product/service in the market and then disappear without clearly fixed obligations and rights of its individual partners.

3.4. Socio-Ethical challenges

At the regional meetings two categories of socio-ethical challenges were identified that must be tackled in order for the VOs to become accepted and supported in different societies. One important category of socio-ethical challenges is related to the establishment and acceptance of the products/services provided by the VOs in the society. Another category of challenges is related to support the individuals that will be involved at any level within the VOs. Furthermore, the detailed challenges that were discussed and emphasized in the regional meetings were of the latter category, mostly focusing on adjustment problems for people to work in VOs. Some of these challenges are mentioned below:

Even today, the development of inter-organizational collaborations has placed more pressure on every individual, to establish himself/herself within its organization. However, the remaining open question for VO is: for individuals that will work in a collaborative environment, whom exactly are they working for, their mother organization or the VO establishment? And where should they establish themselves?

It seems that the developed tools and technologies available so far only support co-working within a single organization, and the social structure behind the co-working is usually not noticed. However, there is no evidence that the mere existence and provision of new tools and technologies are enough to encourage and lead people to work in any great numbers outside of a single shared environment. There is a need to investigate the reasons and drivers to encourage people from different organizations to choose working together in VOs.

Clearly, the issue of trust and personal relationships is crucial to the notion of a distributed workforce. The people (i.e. managers, supervisors, and employees at different levels) must still meet face to face occasionally in order to establish personal relationships, and to enforce mutual trust. Communication cannot be done exclusively on-line, via telephone, or e-mail.

Establishing virtual communities can play a major role in better understanding of what trust is, how to create it, and how trust can be maintained and valued among competitive competencies inside the virtual organization.

The fast spontaneous changes related to comparatively fast changes in configuration of business partners in the VOs, will also generate problems in employment issues. It will lead to increased costs of skilled people, to the growth of the salary gaps as well as to the problems with older and elder employees who will not be able to follow the speed of the technology/organizational changes.

A certain degree of social control seems necessary. There is a need for new institutions (a support network, also called "life maintenance") protecting people from being exploited in the highly distributed, networked manufacturing and service providing organizations. New life maintenance establishments seem necessary to replace the traditional social security and medical care levels.

Many ethical issues need to be tackled, e.g. in connection with transferring employees from one country to another in the case of multinational VOs. The VOs must somehow create an infrastructure in order to avoid the "brain drain". Furthermore, there is a need for a new ethical approach local to the VO for the establishment of networked organizations, since the traditional economic model is no longer appropriate. Current approaches to issues such as anti-trust and unfair competition should be revised.

3.5. Regional versus global challenges

A global perspective to business does not imply that everybody should do the same everywhere; on the contrary it mainly implies very high degree of specialization, which can be leveraged via a world-wide network. Furthermore, certain parts of knowledge and skills will still have a regional-specific nature or "flavor" and certain processes/services need to be accomplished local to a geographic area. This is even true for some highly globalized domains such as the virtual consulting.

The paradigm of VOs should therefore support the development of involved regions, helping to join them in global activities/operations. But this objective requires that an appropriate infrastructure is created in each region to enable the participation of small local bodies in the world-wide networks. This should be a priority goal for regional authorities in charge of promoting regional developments.

In this context, a certain level of public organizations' involvement in regional support to VOs is expected, especially during the starting period, to stimulate the emerging VOs. Priority settings for regions need also to be supported by variety of instruments. For instance, the mere organization of a centralized database of available regional businesses/services (e.g. an electronic yellow pages) is only the first step and certainly not enough. Further support in initiating the VO structures, brokerage, as well as in education of involved individuals is required. This could be a task for the regional authorities and chambers of commerce.

Also, it is of great importance that in connection with the global networked organizations, challenges related to cultural barriers, legal issues differences in habits and traditions, and ways of communication, etc. are properly addressed.

4. CONCLUSIONS

Although most of the contacted experts had difficulties in stating their "vision" for the future, there seemed to be a wide consensus on the characterization of the current situation in terms of collaborative networks and the main urgent gaps that need to be filled and requirements that need to be satisfied. There is a wide industry and academic consensus on the need to progress towards more advanced and pervasive forms of collaborative organizations.

In turbulent markets the new forms of collaboration are seen as the survival factor for a landscape dominantly populated by SMEs. Several forms of collaborative organizations can already be observed in practice, although mostly based on long-term relationships. Furthermore, some new collaboration forms and behaviors are already emerging. However, there is still a lot that remains to be understood and commonly agreed regarding the concept of "virtualization" of organizations in all its facets, requiring the development of multi-facet reference models for this paradigm.

Although the potential advantages of Virtual Organizations are well known at the conceptual level, their practical implantation is still far from expectations. In fact, in spite of the growing awareness of the potential benefits of collaborative networks, still a large number of important barriers or inhibitors persist. These include among others the lack of common reference models, lack of effective interoperability mechanisms and approaches, the fact that supporting infrastructures still require proper characterization, design, and engineering efforts to be materialized, existence of too many offered market technologies and tools with too short life cycles, etc. Furthermore there are major remaining cultural and legal obstacles, a lack of decisive leadership and visionary management in organizations big and small, the definition of ethical principles, and definition of mechanisms that could help *trust building* among organizations, and still too little done on the common VO practices and success stories.

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Please note that the opinions and suggestions made above do not necessarily reflect the opinion of the authors, but rather represent an attempt to synthesize the main conclusions of the various workshops held in different European regions.

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A CHALLENGE TOWARDS VO IN JAPANESE INDUSTRY: INDUSTRIAL CLUSTER

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VO is a key operational issue especially for SMEs to increase their competitiveness through a flexible and dynamic cooperation. In this paper we introduce our current situation on industrial cluster as major VO based activity in Japanese industry. Recently we started to incubate industrial cluster to revitalise Japanese economy. After our investigations, several challenges to realise industrial clusters in Japan are clarified and summarised.

1. INTRODUCTION

Traditionally Japanese industry has been dominated by the "vertical business model" as opposed to "horizontal business model", a sales approach used mainly by American IT companies to market and distribute their multipurpose software and other products across industries all over the world. For example, Japanese automobile industry still has strong long-term commitment in vertical relations throughout their supply chain. The business in SMEs generally depends on their parent companies in such a situation, and they are now in difficult financial conditions under long term economical recession in Japan. It gradually becomes difficult for parent companies to fully take care of their family companies, i.e. SMEs, nowadays.

VO is a key operational issue especially for SMEs to increase their competitiveness through a flexible and dynamic cooperation. The term "Industrial cluster" was firstly defined by Michael Porter as "Geographic concentrations of interconnected companies, specialised suppliers, service providers, firms in related industries, and associated institutions (for example, universities, standards agencies, and trade associations) in particular fields that compete but also co-operate" [1]. The industrial cluster gives us a concrete idea on SMEs managerial style with VO concept in industry. Therefore the concept of industrial clusters has been discussed at both a state and national level for several years in Japan. Recently, industrial clusters have gained added importance as a tool for economic development at a

regional level, because they provide a much richer and more meaningful representation of local industry drivers and regional dynamics.

SMEs within a cluster exhibit strong inter-relationships among themselves. The flow of goods and services between geographically concentrated industries in a cluster is stronger than the flow linking them to the rest of the economy. An industry cluster is different from the classic definition of industry sectors (e.g., construction, manufacturing services, etc.) because it represents the entire value chain of a broadly defined industry from suppliers to end producers, including supporting services and specialized infrastructure [2] [3]. Furthermore, clusters drive wealth creation in the region by exporting goods and services and attracting new wealth from both domestic and international markets.

Recently Ministry of Economy, Trade and Industry (METI) in Japan announced industrial cluster package, and started to 19 projects to develop industrial clusters [4]. They announced the needs for the industrial cluster strategy in Japan as follows:

- Economic revitalization of Japan requires vital regional economy, which is to be realised by innovation, or recombination of activities of business and academia,
- Necessary strategy:
  1) Creation of world class industrial cluster model
  2) Replacement of the older vertical hierarchy in business structure with a network of SMEs.

After such efforts, several industrial clusters have been observed in Japan. In the following chapters we will introduce our current situation about the industrial cluster, as major VO based approach in Japanese industry.

2. INDUSTRIAL CLUSTER IN JAPAN

2.1 Backgrounds

In Japan 'Industrial districts, regional business concentration and industrial agglomeration' is now very popular issue[1], which is widely believed to have contributed to many SMEs' start-ups and development and the formation of collaborating social division of labor network system in the 60s and 70s. Unfortunately most industrial districts are under strong pressure and difficult to survive. Therefore, new academic ideas are requested how to interpret the essential meaning of industrial districts and business linkage, such as 'flexible specialization and social reconstruction of market' debate or 'industrial cluster' model, how to reorganize them to adapt to the globalizing world economy and IT revolution, and how to support them with local industrial and regional policies. 'Social economy', local human networks and NGO activities will be also involved to organize new local communities, as well as SME's social role and contribution.

Internationally competitive 'industrial clusters' will be created under a close affiliation between the industrial cluster plan formulated by METI and 'intellectual

[1] The same concept as VO breeding environment.

clusters' creation initiatives put together by the Ministry of Education, Culture, Sports, Science and Technology (MECSST) [5], as follows:

(i) Industrial Cluster Plan
Outline: To promote the formation of a wide network among industry, academia, and government for corporations that aim to enter the global market; and to contemplate the development of new businesses and the formation of industrial clusters through the promotion of technological development that makes the most of regional characteristics.

(1) Promotion of 19 projects nationwide:
- Number of participating corporations: about 3,700
- Number of affiliated universities: about 190

(2) Formation of a human network: 4.4 billion JP yen
(3) Technological development that makes the most of regional characteristics: 22.9 billion JP yen
(4) Construction of facilities to educate entrepreneurs and that offer circumstances for starting new businesses: 7.9 billion JP yen.

(ii) Intellectual Cluster Plan
Outline: To aim to create clusters for technological innovation with international competitiveness by corporations that engage in research and development. Public research institutes such as universities are positioned at the core of this cluster.

(1) Number of areas where projects are conducted: 10 areas in Japan (an additional six areas have been designated the "trial area")
(2) Scale of projects: approximately 500 million JP yen per area (about 100 million JP yen per year for the "trial area")
(3) Period of business: five years (no more than three years for the "trial area").

We will especially focus on the industrial cluster plan of METI due to the economical scale in this section.

2.2 Objectives

There are two major objectives for the industrial cluster plan in Japan.

(1) Revitalization of the regional economy

To revitalize the regional economy is indispensable for the Japanese economy in order to achieve sustainable mid- and long-term growth. Especially as the regional economy is severely suffering from the prolonged depressions and the tight financial restrictions, the revitalization process in regional aspect needs to be urgent.

(2) Creation of the new business to foster globally-competitive industrial clusters and to improve regional competitiveness

Development of the new industry is a driving force to stimulate the growth potential in the region. The industrial cluster plan aims to foster local clusters of industries by creating globally competitive businesses in the region. In order to

achieve the goal, the Regional Bureaus of Economy, Trade and Industry (RBETIs) in cooperation with the local governments started to lead the following measures:

- To formulate the human network among the academy, the business and the governments
- To provide various policy measures, such as R&D funding, effectively and comprehensively.

2.3 Incubation process of industrial cluster

It has been revealed that there consists of four stages to create industrial clusters effectively by the investigation about Japanese case:

i) First stage: Preparation of cluster formation
Search for new combination of unit companies and institutions, and their business resources
ii) Second stage: Formation of cluster core
Organisation of a competitive core group through conference, R&D project, and etc.
iii) Third Stage: Clustering
Promotion of networking of unit companies and institutions in business activity
iv) Fourth and last stage: Establishment
Establishing the clusters, and expand & aggregate them.

Coordinators must play an important role to formulate clusters. They should maintain an attitude of strict neutrality at the preparation period. Therefore some voluntary-based groups, local governments, or NPOs, are suitable for the coordinators at the first stage instead of professional agents in Japan.

2.4 Classification of Japanese industrial cluster

Our observation suggests there are obviously four types in Japanese industrial clusters as follows:

Type 1: Basic technology initiated
Basic technology driven market
Type 2: Consumer oriented
Market conscious collaboration
Type 3: Collaboration for the orders
Flexible response for specific orders
Type 4: Industry - academic collaboration initiated
Hi-tech or biochemical industry.

Type 4 must have strong relationship to 'Intellectual cluster plan' described in 2.1. The integration between industrial cluster and intellectual cluster could produce higher values for the local community with synergy effects.

2.5 Business models in Japanese industrial cluster

We have several kinds of business modes in Japanese industrial clusters, which are

categorized as follows:

i) Horizontal business model
Kyoto prototype industrial cluster (Kyoto)
- 10 companies
- Focus just on prototype
- Quick response with specific request
- Value added manufacturing skills are required

ii) Vertical business model
Rodan21 (Higashi-Osaka)
- 19 companies (3 groups, Design, Manufacturing, Distribution)
- Focus on cooperative E-Commerce site from design to distribution

Hyogo welfare industry network (Hyogo)
- 17 companies, 2 foundations, 1 union, 2 local governments.

Strategic & careful selection of the business model is quite important to set up an appropriate industrial cluster. Deep consideration and prudent analysis on their products or services are required to realize successful industrial clusters.

3. CHALLENGES TOWARDS THE NEXT STEP

According to our investigation about Japanese conditions, we summarise the challenges for the next step to stimulate industrial cluster project in Japan as follows:

(1) Local companies need collaboration in new business fields

The business fields with high-growth potential shall be those of high risks and high returns and require development of new products, new services, and new technologies based on innovative ideas. Local companies, therefore, may face the difficulty to enter such a risky field and to survive in the global market without any collaboration.

(2) Formulation of the human network among the academy, the business, and the governments is essential

To develop regional industrial clusters, it is essential to formulate effective human networks among the academy, the business, and the governments, such as local companies, universities, public research institutions, venture capitalists, and trading companies. The human network contributes to raise the quality and quantity of distributed information among the parties and to supplement management resources of local companies in the light of technologies, management information, sales, etc.

(3) Public sector becomes a node of network and provides effective policy measures

To form the above-mentioned human network, public sectors take an active role as a node of the networks, by visiting key persons in the region and collecting various information such as development needs of local companies and technology

seeds in universities. Based on the accumulated information, public sectors provide comprehensive and effective support measures including regional R&D funding.

(4) Important frameworks

i) Human networks formation in wide area

- To promote exchange of technical and other useful information originally owned by local companies, universities, and public research institutions by utilizing the data base, common web pages, etc.
- To provide place of exchange and collaboration among local companies, universities, public research institutions, trading companies, and other supporting organizations. (Examples are to hold some workshops on the latest technology issues and to arrange seminars for university-industry collaboration).

ii) Support of cooperation and collaboration between local companies and universities and between companies in the field of R&D, new product development, market research, etc.

- To promote regional R&D initiatives utilizing local resources
- To support development of practical application technologies by forming consortia of local companies, universities and public institutions
- To support regional companies for their R&D on innovative products.

iii) Preparation of business incubators

- To provide business incubation facilities to support start-up businesses in the regional clusters
- To nurture and dispatch incubation managers for those incubators to provide business start-up know-how.

iv) Other supporting measures

- To introduce trading companies to local SMEs for sales and marketing cooperation
- To dispatch experts in management to local SMEs
- To introduce financial institutions for investment, loan and debt certification to local SMEs.

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COLLABORATIVE NETWORKS IN AUSTRALIA – CHALLENGES AND RECOMMENDATIONS

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Australia is a country with a size comparable to Europe but with less than 10% of the inhabitants. Low-density population results in relatively high cost of infrastructures and small domestic markets. Over the last ten years, Australia has moved from a locally oriented economy to one that operates as part of the global business environment. Australian companies, large and small, take this opportunity to form alliances with international partners in order to participate in large-scale overseas projects. The most significant challenge facing Australian researchers in the next decade is the understanding of the collaboration in this complex and dynamic international business network and to put it into successful practice. Through our recent projects in global enterprise networks, we recommend the key research areas on collaborative networks to be the design of extended enterprise, technologies for the integration information and knowledge across company boundaries and the support to people in collaborative decision-making.

1. INTRODUCTION

1.1 Australia – a continent with distant centres

With a quick look at the globe one soon realizes that Australia is a country with a size equivalent to the USA or Europe. Its population is nevertheless less than 10% of either of those. The continent is sparsely populated and 80% of the inhabitants live in 5 major city areas, which are 800~3,500km apart. The air link between Melbourne and Sydney (800 km distance) is the second busiest in the world. Reducing travel between major cities would increase productivity in business, engineering, finance and project management.

Another important political imperative in the country is that small and medium businesses from regional cities should be better integrated into the national economy. Australians like open space. People like living in the country. Living conditions in small cities are attractive for independent professionals as the house prices and the living expenses are lower than those in the major urban centres. This is in addition to the special attractiveness of the country life.

The ICT infrastructure is very well developed in the country. Urban centres are well served with high bandwidth optical fibre connections. Microwave links and

satellite systems will soon serve the most distant rural areas. The use of computers in both industry and professional use is wide spread. Businesses and intellectual workers are using the Internet every day for gathering, sharing information and for business transactions.

1.2 Australia – part of the international business community

Significant part of Australia domestic national products is realized in global businesses. The domestic market is small therefore products, produce and raw materials are strongly interwoven into the global trade. We have to export goods in order to maintain and further develop our manufacturing capabilities. We import goods that we cannot make profitably here. Many Australian companies are in the global supply chain, delivering components to automobile and aerospace industries in Europe, Asia and USA. Strong daily cooperation in business transactions, in the engineering and finance is a characteristic feature of the Australian life. Australia enjoys a significant advantage, as its east coast lies on a time zone, which fits perfectly well into the "round the clock business" principle with partners in Europe and USA. Its business centres can communicate during the daytime with it's Asian neighbours. Their employees can work while their counterparts in Europe or USA are sleeping or resting.

Small – medium sized companies are forming *hard networks.* Their aim is to establish links between enterprises with varieties of skills and capabilities. They can create virtual enterprises from their combined pool of resources easily. They are now convinced that in this way they can bid for larger international contracts that previously were thought impossible.

The large multinational companies operating in Australia have their head quarters overseas. Their operations in our country are synchronized in every aspect with that of their parent companies.

1.3 Australian economy needs collaborative networks

From the above short introduction to the Australian way of business life it should be obvious that companies, government and business institutions have been using Collaborative Network Technologies for some time as the State-of-Art permits. We realized these needs and the shortcomings of the available ICT tools long ago and established collaborative research projects with European, American, Canadian and Japanese partners in the early nineties. We developed tools, tested commercial products, studied the human aspects of collaborative work across large distances, time zones, and cultures. We identified that technology works well within certain economic, political and social boundaries if they are tuned to the demands of the human aspects. These international projects have taught us what sort of tools and methods are available, where the commercial developers are moving and what are the burning research issues we have to face. We are in contact with research institutions worldwide and have identified the niche areas to be explored. We are constantly updating and reviewing our research partnership with universities and companies.

2. GRAND CHALLENGES FOR COLLABORATIVE NETWORKS -- VIEWS ON DIFFERENT HORIZONS

There are many views on the major challenges in the collaborative technologies. We consulted the Australian research community to understand the expectations of local users, identified the overseas research directions and estimate what commercial products will be offered in the coming years. The following summary contains the hurdles that we need to overcome.

Globalisation of manufacturing will require many companies, particularly SMEs, to provide one or more specific core capabilities within global alliances. Australian industry must be able to participate in these virtual enterprises in response to the continual dynamics of global market opportunities. Of critical interest will be design of the extended enterprise, network information management, scheduling and coordination, and the ability to make adaptive supply networks robust, stable, and performance optimised.

More than ever, operating conditions will be characterised by *frequent change* in product, process, market or supply and distribution networks. Success therefore also depends on well-coordinated agility in all internal aspects of a geographically distributed enterprise. For such agility, aspects of critical importance are techniques for rapid product development, adaptable and robust production systems and the related information and decision support systems.

Collaborative networks link *people* together. Addressing human aspects is sometimes more difficult than developing new technology. Special attentions have to be paid to agreeing on common goals for collaborative teams, building consensus between team members, defining the role of leadership in a multidisciplinary team and share non-codified knowledge and practices. However, understanding cultural differences and assistance to overcome language barriers are still problems.

The *risk* to manufacturers lies in limited resources being devoted only to efficiency improvement of current approaches, rather than to evolution of new ways of business operation and rational strategies of migration to new approaches. These risks have to be demonstrated and tools have to be developed to mitigate them.

3. KEY RESEARCH AREAS

Based upon the available resources and building on the strength of our results we have prioritised our strategic directions of "Enterprise Structures and Operations" (Nemes 2000). The CSIRO Divisional Management approved the *Complex Systems Integration* Core Capability Strategic Research Plan in 2003 (Nemes 2003) along the following strategic objectives.

1. Understanding the behaviour and performance of highly dynamic distributed enterprises (complex collaborative networks) and characterising the influences of key factors. This will provide fundamental insights into the most appropriate architecture on which to base such enterprises, as well as the decision support requirements for the management of complete supply network life cycles.

2. Creating a theoretical foundation for robust agent-based manufacturing systems. Complementing the preceding distributed enterprise topic, system architectures are fundamental and must also be supported by design methodologies, especially design principles for obtaining appropriate emergent system behaviours from multi-agent systems.
3. Characterising manufacturing domains that are receptive to an agent-based approach; potential advantages and migration strategies.
4. Developing performance metrics for, and stability of, distributed system control in dynamic environments.
5. Defining and establishing coordination protocols, control mechanisms, risk assessment and algorithms for conflict resolution in a global dynamic environment.
6. Investigating architecture and performance of corporate knowledge management systems. One focus here is the integration of information in the complex collaborative networks. Good integration is crucial for cooperative decision making and inter-enterprise resource management to provide high quality global customer support, service and problem resolution. A complementary requirement is to underpin the full range of decision support needs associated with supply network life cycles.

4. PLANNED ACHIEVEMENTS

The CSIRO strategic planning procedures require pointing out two aspects of the proposed works. The "outputs" defines the results coming out of the research process. These are the expected scientific achievements showing that the research is focused on novel areas and worth to be done in our government funded research organisation. The "outcomes" are the other aspects of the planned research activities. These state that the research will have potential impacts on the Australian Industry.

4.1 Expected outputs of the research activities

The following research results will be delivered in Australia and will be applied in conjunctions with research results overseas and combined with industrial products:

- *A methodology for migrating traditional hierarchical systems to distributed environment.* That strategy will allow users to make transitions from existing operational structure to distributed environments. The existing infrastructure and capital items can be viewed as a black box and new components can be added to it as cooperating agents. By adding / removing agents the new section can renew itself. The traditional system finally will be written off and removed.
- *Protocols and procedures for distributed cooperative systems.* There will be investigations on how flexible protocols can be, what the mechanism for negotiation procedures would be for agreeing on common protocols between autonomous units.
- *Specification of knowledge management requirements for virtual enterprises.* We shall investigate technologies for capture, formalisation and management of corporate knowledge. It is an important issue for companies not only to manage what they know, but also be aware of what they need to know. The capture and formalisation of knowledge have to go beyond the boundary of a single enterprise and should embrace the whole network of partners. In other words

the question to be answered is how to deal and treat the inter-enterprise or global knowledge.

- *Modelling methods for performance analysis and stability control for distributed enterprises.* The rapid formation of virtual enterprises provides great advantages for participants. Once the mission is fulfilled the partners would want to free up the resources as quickly as possible since they would like to explore new opportunities. The formation process is a difficult one since all enterprises are looking for partners in many networks and checking numerous opportunities for choosing the best from them. This highly dynamic formation process has its problems. It may well happen that when the offer comes from the consortium, the company resources are not available any more as they are committed elsewhere, so the consortium has to approach an alternate partner. Another example for the difficulties is when the consortium is working already, cooperating partners may drop out for economic or other reasons. The missing resources have to be replaced and trained up to speed quickly. More importantly, the operation should not be delayed. Research outcomes from modelling tools and metrics will enable quick analysis and fast response to such dynamic behaviours.
- *Generic enterprise reference architecture for dynamically changing global enterprise.* The static view of Generic Enterprise Reference Architecture and Methodology (GERAM) will be extended to model the dynamic view (ISO 1998). The research issue will be how to use the framework to model and visualise the global network in providing business information for the management.
- *Major advances demonstrated in industrial trial.* The funding bodies expect that major advances in research should be periodically demonstrated to industry. It is also extremely important for us to test new methods and software tools in an environment, which could provide useful feedback to us. We are happy to discuss these requirements with overseas partners and propose joint international demonstrators in these areas.

4.2 Outcomes for the Australian industry

The long-term outcome of this research is the realisation of a broad base of competitive Australian companies with the structure, knowledge and tools to participate in ever changing global cooperative networks. This may involve various functions of a manufacturing enterprise, including management, marketing, sales, product design, facility engineering, component supply, assembly, distribution and customer service.

To facilitate this, system providers will offer a selection of open (interoperable) information, knowledge management and decision support systems designed to underpin end-user flexibility and agility, such as:

- A system to assist Australian industry to take a structured approach to participation in global manufacturing networks.
- A suite of inter-enterprise management tools that will help Australian industry contribute to the competitiveness of global networks.

- Manufacturing engineers and system integrators offering advanced, agent-based production systems that are not only reconfigurable, flexible and robust but which also enhance quality and productivity.
- Industry projects demonstrating the elements, methodologies and technologies of concurrent engineering practices, new control architectures, and migration paths to their adoption.
- Extensive adoption of concurrent engineering practices in Australian industries for highly competitive rapid product development.

5. BUILDING R&D CAPACITY IN AUSTRALIA

CSIRO has been working in enterprise engineering since the late eighties. We have participated in the development of the GERAM framework (Bernus 1994) and have developed proof of concept systems for collaborative intellectual networks. Such systems have been demonstrated in industry for preparing bidding documents, rapid formation of projects in virtual enterprises, testing interoperability and estimating risks for multi site engineering. During the coming years the following research capacity will be developed:

- A comprehensive computer modelling and simulation capability will be established for multi-agent concurrent systems.
- Infrastructure and expertise will be developed in communication technologies to support collaboration between geographically separated groups.
- The work enhances existing key skills in systems analysis, simulation and modelling, information technologies, particularly in communications and electronic commerce, knowledge management systems and human-computer interfaces.

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A BRAZILIAN OBSERVATORY ON GLOBAL AND COLLABORATIVE NETWORKED ORGANIZATIONS

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This chapter introduces a summary of the current status of the Brazilian situation in what concerns global and collaborative environments. It then highlights some challenges and associated needs as well as proposes some recommendations with view to speed up and to improve the adoption of the Collaborative Networked Organization paradigm in Brazil and in neighborhood countries.

1. INTRODUCTION

This chapter intends to give an idea about the current status on what is going on in Brazil with regard to research, development, best practices, available infrastructure as well as national policies and initiatives in the field of Collaborative Networked Organizations (CNO). A CNO is here basically seen as a group of actors (for instance, institutions and industries - from public or private sectors - independent professionals) that have the will to collaborate through the network to attend a business opportunity or a common interest making use of computational support such as the internet and/or other collaborative platforms.

The perceptions presented in the text are the most representative for the authors although they surely do not represent the totality of the actions on CNO being carried out in Brazil nowadays. A wider perspective can be achieved by the readers by accessing some of the links provided along the text.

Furthermore some emergent challenges are also pointed out and their associated needs are mentioned. Finally some recommendations in order to cope with the challenges and needs are highlighted.

The work is organized as follows: Section 2 presents a generic overview of the CNO scenario in Brazil which is, in the sequence, further analyzed in the next chapters under three perspectives: Section 3 focuses on the knowledge workers, Section 4 addresses the existing and the needed infrastructures, and Section 5 presents some Brazilian policies that are in somehow linked with the CNO concept. Finally, some global conclusions are presented in the last chapter.

2. WHERE WE ARE ... STEP BY STEP

Even considering the relative infancy of this electronic scenario in Brazil, the B2B transactions (from e-procurement to e-sales) carried out by the 30 largest Brazilian companies (responsible by almost 90% of all transactions) have traded more than 10 US$ billions in the first six months of 2003 (Business Standard, 03). Nevertheless, the B2B scenario is still accomplished in the "traditional" way, one-to-one, i.e. two enterprises that make business electronically without a connection with a supply chain or virtual enterprise, for example, meaning that the execution of the joint business is not globally and cooperatively coordinated. The enterprises use to make their transactions via web portals, such as COVISINT (automotive sector: www.covisint.com), building sector: www.estrutura.net, metal-mechanic/machining sector: www.e-cimm.com.br., and the Brazilian e-government: www.redegoverno.gov.br.

Actually the life of a CNO follows a cycle that starts with the mobilization of one or more organizations towards a common goal, even among only two enterprises. This joint objective may represent at the end of the CNO life-cycle a tangible or intangible good – in the best case you have both! You may have an extended product (Hirsch *et al.,* 2001) as the main result or you may have common research and achievements through the network of institutions of excellence. Aside from how concrete, tacit or explicit these results can be, the CNO have their life based on common phases (Camarinha et al., 99) (Spinosa et al., 98) (Camarinha et al., 03): mobilization, creation/configuration, operation/evolution and dissolution.

In the Brazilian experiences on CNO the progresses being observed in each phase are quite different, usually reflecting interests of individual researchers and few research groups involving some pilot enterprises. The three phases where the most concrete/practical results have emerged are mobilization, creation and operation/evolution.

The uppermost examples of mobilization in Brazil come from two so-called "breeding environments" (www.vomap.org), namely:

- VIRTEC (www.dep.ufscar.br/pet/boletiml.htm): the VIRTEC project (Technology Virtual Organization) was born at São Carlos School of Engineering of University of São Paulo as a pioneer initiative in Brazil. It aimed to allow its members to leverage their competitiveness by searching and exploiting business opportunities as well as the formation of virtual enterprises. The Global Virtual Business Model (Mundim *et al.,* 2000) was used by VIRTEC and, although no longer active, VIRTEC is still considered a Brazilian best practice in the mobilization field, acting as a reference case for other initiatives.
- VIRFEBRAS (www.virfebras.com.br): The Brazilian Virtual Organization of Tooling Companies is an initiative of the University of Caxias do Sul with view to increase the business potentialities of the enterprises from the mould and die sector (Lima et al., 03). To this end, nine enterprises from the South of Brazil compose VIRFEBRAS working on a collaborative way, having common goals but keeping their own identities. VIRFEBRAS is an active breeding environment which works in a tight relation with universities and

research centers trying to find solutions to cope with the challenges brought up by this new way of doing business.

Following the CNO life-cycle, the GSIGMA group (www.gsigma-grucon.ufsc.br) is one of the most active in the creation and operation/evolution phases of CNO. This research group from the Federal University of Santa Catarina was created in 1996 and since then carries out activities related to CNO in the fields of the metal-mechanic (PRODNET-II Esprit project [www.uninova.pt/~prodnet], IFM project [www.ifm.org.br]), textile and shoes (DAMASCOS IST project [www.inescporto.pt/~damascos], MYFASHION.EU IST project [www.myfashion.org]), furniture (SMART-FM project [www.funstep.org]) and agriculture (SCM+INCO-DC project [www.uninova.pt/scm+]) industrial sectors.

The GSIGMA's main achievement is the **SC²**, a (desktop and web-based) system for supply chain (SC) management that helps the SC manager during the SC operation/evolution phases. **SC²** was developed based on the business intelligence paradigm allowing the SC participants to access information - available at different (configurable) levels and according to some visibility criteria - about the whole SC improving the transparency of the joint business, raising the trust building process among the involved actors and strengthening the partnership links and commitment (Rabelo et al, 03b).

Other institutions that are also working on CNO or in themes related to the subject are:

- University of São Paulo (USP): http://www.poli.usp.br/pro/redecoop
- Carlos Alberto Vanzolini Foundation: http://www.vanzolini.org.br/areas/logistica.html
- Federal University of Santa Catarina, Transportation and Logistics Laboratory: http://www.eps.ufsc.br/lab.htm
- Methodist University of Piracicaba (UNIMEP): http://www.unimep.br/feau/ppgep/

2.1 Challenges and needs

There are still several steps that have to be taken before "claiming" the right to be a country where CNOs exist and co-exist in a sustainable environment. But each step has to be taken one after the other. The first one is the mobilization, i.e., people and organizations have to raise awareness about this new working environment, its advantages and its implications. The surrounding has also to be prepared for this. Infrastructure, workers and customers are part of this surrounding and need adaptations, improvements and respect from all sides.

The establishment of breeding environments is in its beginning. In spite of some results derived from the success of putting companies within the same framework / environment, it has been realized that it is a long journey. In some cases the results a company can achieve with its involvement in the breeding environment are over estimated. In part it is because the companies often do not have a deep acquaintance about the meaning of being a member of a CNO. Besides that, as the current environments in Brazil are mostly composed of SMEs, the companies' business mentality actually is not so different than the one they had before belonging to the CNO as they keep reticent to share their knowledge and information (like prices,

stocks, order status and capacity) with the other members. Therefore, there is a clear need to reinforce the trust aspect among the CNO members so that the cooperation can be achieved more effectively, regarding the entire CNO life cycle. This issue is further stressed in the next chapter.

2.2 Recommendations

In order to spread out CNOs in Brazil it seems to be necessary a strong dissemination and awareness campaign in order to provide to the potential beneficiaries the adequate information and the needed answers. Workshops, conferences and training on the theme could be seen as facilitators and may constitute a strong mechanism to achieve this challenge. Research and development projects should also be stimulated in order to bring Universities, Research Centers, software houses and enterprises to work together on this theme. Topics for these proposed actions should include among others issues to reinforce the trust building process, such as responsiveness levels, ethical and legal cares, IPR, full product life cycle responsibility, etc. They need to be gradually and slowly pursued by the companies towards a more transparent CNO from the legal, operational and financial points of view.

3. KNOWLEDGE WORKERS NEEDED

The application of the CNO concept introduces, from the social and organizational points of view, new needs in terms of methods and contents of work as well as skills of the human resources involved.

Although one could say that the need for knowledge workers is not new (Peter Drucker, for instance, has been writing about the advent of knowledge work and knowledge worker since 1954), it is a fact that in the CNO environment a "powerful" combination of cultural and organizational changes makes this kind of skilled worker even more needed and, at the same time, the hunt for him/her even harder.

CNO encourage people to participate throughout the net in decision making upon a business process, exploiting the synergy necessary to satisfy the customers as well as the final consumer. Concepts such as collaboration, trust and team work have to be realized by all the involved actors.

3.1 Challenges and needs

People will have to adapt to their new roles. CNO brings new requirements in terms of expertise to accomplish its associated activities. These activities, such as distributed business processes management, on-line negotiation, re-scheduling, information requests, information reception and rapid decision-making guided by customer demand, and the constant changes imposed by the markets, etc., will be performed more and more with the support of computer tools, usually strong linked to a network (such as the Internet). Hence it will require a continuous training of people as well as the adaptation of some functions (in their nature, levels of

responsibility and decision-making, and number of people / procedures involved) according to the information technology (IT) needed, available and used, based on a sound methodology as well as on consistent principles and foundations.

3.2 Recommendations

One of the first steps is to provide methods to integrate, manage and coordinate multiple and cross-functional virtual teams as well as their activities. Then it is necessary to make individual learning becomes collective learning and thus part of the organizational culture. This is not a short-term process and requires, besides the time, the will of the whole team to understand as well as to learn about and with the value changes brought by the CNO environments. Additionally, an important aspect to highlight is the lack of more comprehensive managerial methods to support the CNO technical *mentor* in this new business scenario. This would be very helpful to reinforce the trust aspect as the actors involved are usually inexperienced on that model and hence they generally coordinate actions in a CNO in a *learning-by-doing* way.

These changes will surely be reflected in aspects such as: motivation, participation, autonomy and delegation of responsibility, qualification and negotiation –just to mention few of them. All this will have to be reevaluated.

4. ICT INFRASTRUCTURES

The main aspect to be faced regarding ICT infrastructures in Brazil seems to be common in several other countries in Latin America: ICT is expensive and plenty of new IT appears every day in the market claiming to be the most updated ones. This has created a very skeptic attitude from the companies - especially SMEs - as they do not use to have an expert on ICT management to advise them about the most suitable technologies, their life time, current requirements, and so forth.

From the communication infrastructures point of view, the situation in Brazil is well served so far, especially in the medium sized and large cities where most of the enterprises are located. After the privatization of the telecommunication services some years ago better backbones were put available both to public and to private networks. Besides that, several ICT companies appeared in the market offering more specialized communication services, such as satellite, cable, radio, etc., enlarging the possibilities for the enterprises to balance needs and costs.

The number of Brazilian enterprises that currently make use of computers in their day-to-day activities is relatively large regarding that most of them are SMEs - 47% of them have a PC (it was 19% ten years ago) and 53% from this are connected to the Internet (www.camara-e.net/templates/inclusao_sp.asp). The more the enterprises begin to intensively use the network to make and to manage their business, the more overloaded the communication infrastructure already installed will naturally become.

In terms of IT, several enterprises opt to follow their holdings in order to support the communication among their branches. Other enterprises are clients of the main world-wide software-vendors. In this last case, the suppliers – usually small

companies - are often requested to adapt their system to or to provide an interface to communicate with the dominant software.

Another aspect to be faced has, once more, cultural origins. As the CNO area / business model is still incipient and with very few supporting tools available in the market, several enterprises believe that such a tool is just an ordinary commercial off-the-shelf software, easy-to-use, plug-and-play. Besides that, most of the enterprises have focused their actions towards CNO environment purely on technology aspects leaving other essential issues, such as organizational culture, on a second plan.

Regarding the current status of software development on this area in Brazil, the IT solutions to support the CNO business model are still costly and not easy to configure and to use. The reason for that may relay on the fact that there is still a long list of open points on the CNO field and that, therefore, the work is far way to be finished.

4.1 Challenges and needs

The enterprises need to be confident in a given model or technology in order to apply it. As the amount of enterprises that is expected to work in a CNO tends to increase highly, the need for easy-to-use, low cost and interoperable solutions as well as for more robust computer networks will indeed be required. It will demand higher investments on supporting infrastructures from the private ICT companies and from government, especially when considering that image and sound will also be exchanged in the CNO.

From the systems development point of view, one of the main challenges is to provide the enterprises with highly and transparent configurable systems, easily installed and integrated/*pluggable*, and whose execution can be based on standard business processes.

There are some other very important and more recent initiatives / technologies whose impact on the CNO will create new needs and challenges: the GRID technology, and the mobile communication.

The GRID technology can be defined (Foster et al., 01) as a flexible, secure, coordinated resource sharing among dynamic collections of individuals, institutions and resources, refereed as virtual organization. This technology still has a long way to go through before having its potentialities widely and deeply exploited by CNOs. In Brazil, there are currently 21 projects on GRID (Cime et al., 02) which can be divided into three groups: validation, development, and applications. The first one aims at putting available for a cluster of individuals an existing infrastructure operating in a GRID-oriented way in order to evaluate its general performance. The second one concentrates on developing a GRID infrastructure and an access middleware. The last one aims at analyzing how different application domains can benefit from such technology, namely the weather forecasting, the genetics and the physics experiments. Cime concludes that a further step should be done now on the direction of making the GRID technology easily available for ordinary people as well as for enterprises.

In what concerns the mobile aspects, it is common sense that enterprises from all domains of application can really benefit from the mobility and the freedom offered

by this technology. A wireless workforce allows information to flow immediately and freely between off-site employees and the home office (Brans, 02). Nevertheless, this area is full of alternative protocols and the technology has been evolving quite frequently, creating serious difficulties for its wider adoption and for systems maintenance by the enterprises. Most of the customer's concerns tend to revolve around order status issues: order receipt, time to delivery, picking status and shipping information. It means that the solutions available in the market nowadays allow a customer to follow up a given order by means of accessing a web server with a private and secure password. Based on this current situation, one of the CNO challenges is to foster the utilization of mobile technology in the coordination and management aspects, also providing the enterprises' managers with different levels of information visibility according to the specific mobile device (s)he is using.

Finally, the challenge related to the legal and security aspects associated to the electronic transactions has been always emphasized by the enterprises as a reason to be afraid of sharing information through the net / within the CNO. The need here is to find a suitable way to make the entrepreneurs to see, to test and hence to believe in the technology even though some risks may exist.

4.2 Recommendations

The authors believe that some initial steps could be done by the software vendors. They should for instance design their supporting solutions for CNO in a more flexible and easy-to-install & to-configure way in order to speed up the assimilation of the technology and model by the enterprises, especially the SMEs. They could also conceive the systems in a more modular way / with lower granularity so that the enterprises could only use (and pay for) the strict set of functionalities they need for a certain period of time, as proposed in (Dutra et al., 03). Additionally, if one of the main goals is to have software of good quality, ideally they should be developed by CMM (methodology) certified vendors.

It is a common sense that generic models are needed to leverage the collaborative work in the CNO. Brazilian researchers, institutions and other opinion makers actors should be more active in their involvement in international initiatives (such as COVE and Rosettanet) on CNO models, methods and metrics that can be incorporated into the software in the near future, allowing an easier processes interoperation.

Finally, Brazil has a huge task being done on legal and financial aspects related to CNO (htpp://ce.mdic.gov.br). However, the approval of a legislation for electronic transactions is strongly recommended as it can facilitate and better guide all those who want to adopt this new organizational and business model[1].

5. BRAZILIAN POLICIES & INITIATIVES

The Ministries of Science and Technology (S&TM) and of Development and Trading (D&TM) have leveraged several initiatives aiming at preparing the country to the digital era in the CNO context.

S&TM has funded some pioneer projects on CNO, where the most important initiative is the IFM Project (www.ifm.org.br). The Institute Factory of the Millennium is a 3-years project which aims to conceive, to implement and to disseminate methods and techniques that help enterprises placed in Brazil to become more competitive. Its actions are focused on four main areas of strategic development. One of these areas is supply chain management / CNO. More specifically, the CNO subgroup has been researching methodologies, best practices, systems requirements and policies / guidelines to better advise the project end-users. All these also intend to help the government in the conception of dedicated policies which will benefit the Brazilian states. The states, in turn, are nowadays - in an independent way - identifying their supply chains, clusters and other forms of enterprise organizations. This action intends to facilitate the understanding on how the supply chains work and how they behave according to changes in the financial legislation, and which policies can be introduced to make them more competitive. IFM is more an applied-research project.

The D&TM is also supporting some initiatives that will help the establishment of the CNO concept in Brazil (htpp://ce.mdic.gov.br). Four projects - called as Innovative Projects on E-Commerce - were created focusing on exportation. The main objective is to increase the exportation rate and to make potential Brazilian exporting enterprises more visible and known for the foreign market. Three different segments are specially addressed in these projects: the textile industry, the companies that produce photographic / natural images from Brazil and the transportation sector. Additionally, a general portal presents the Brazilian enterprises registered to export.

Another governmental effort is related to the information security area. The ICP-Brasil (www.iti.gov.br) - the national public key certifier, which is strongly grounded by the Brazilian Chamber of Electronic Commerce (www.camara-e.net) -, is for instance very active in this subject.

5.1 Challenges and needs

Most of the challenges and needs under the perspective of national policies and initiatives relays on the creation of critical mass – both at the public as well as at the private sectors. More actions in this direction should be planned and put in place by the national government. If Brazil wants to be part of this competitive and dynamic knowledge-based economy which is taking form nowadays, this should be translated in political goals, initiatives and programmes.

5.2 Recommendations

The CNO model is recent but it seems irreversible in the globalization movement. As the SMEs are responsible for more than 80% of the formal employment and they represent more than 98% of the enterprises in Brazil, the creation of specific governmental programs is important to fructify critic mass on the theme and to prepare the enterprises properly. The investment therefore in information and knowledge technologies should follow this tendency in order to contribute and to accelerate the creation of a Knowledge Society able to promote sustainable

economic growth and to attend to people and society's needs. This does not need to be necessarily a centralized initiative lead by governmental ministries. It can for instance be done making use of the large capillary that some organizations have crossover our huge national territory, namely SEBRAE (The Brazilian Support Service for SMEs, www.sebrae.org.br), CNI (National Federation of Industries, www.cni.org.br) and its local branches, Senai (National Service for Industrial Training, www.dn.senai.br), and the foundations for research support presented in each State (such as Fapesp, Faperj, Fapergs and Funcitec).

6. CONCLUSIONS

This paper described the current status of the Collaborative Networked Organizations (CNO) in Brazil. It did not intend to cover all the initiatives, but rather to provide a general view upon what the authors consider the most representative.

The work comprised initiatives carried out by research institutes, companies and the Brazilian government, stressing the essential perspectives on CNO in Brazil namely people, infrastructures and technology as well as local supporting policies.

The main conclusion that comes up with this observatory work is that the implementation and further adoption of a business model such as the one envisaged by CNO must be accomplished by some fundamental elements, namely: the technological, organizational, human and cultural aspects. The technology is improving world-wide and also in Brazil. The most "abstract" aspects (organizational, human and cultural) are harder to be tackled. A synchronized effort is therefore necessary so that the most advantages can be taken from the CNO environments. The journey is long but worthwhile and feasible.

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[i] The reader can reefer to some of his books such as: *The Practice of Management* (1954), *Landmarks of Tomorrow* (1959); *Managing for Results* (1964); *The Age of Discontinuity* (1969); *Management* (1973); *Toward the Next Economics and Other Essays* (1981); *The Frontiers of Management* (1986); *The New Realities* (1989); *Managing for the Future* (1992); *Post-Capitalist Society* (1993); *Managing in A Time of Great Change* (1995); *Management Challenges for the 21st Century* (1999); *Managing in the Next Society* (2002).

[1] Actually there is only a project of law from 2001.

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SOME AMERICAN RESEARCH CONCERNS ON VO

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Enterprise Integration researchers in the U. S. appear to have a different set of priorities and interests than their European colleagues. We briefly speculate why, outline the differences and describe some consistently noted research concerns.

1. INTRODUCTION

No one can speak for the North American research community of course. But we do have the handy experience of ten years with the International Conference on Enterprise Integration Technology. That exercise was initiated to develop research roadmaps for both sides of the Atlantic, recognizing differences in approach and with the majority of applications of the "virtual enterprise" type.

This report is drawn from observations of participants of those gatherings on asymmetries between the two communities, their approaches and interests. Remarks on the origins of the differences should be read as somewhat anecdotal. In contrast, the outlined research topics themselves are summarized from a highly refined, even tedious, consensus process (Petrie 1992, Kosanke and Nell 1997, Kosanke Roland Nell and Bas 2003).

2. ASYMMETRIES IN INTERESTS

Infrastructure research for virtual enterprises in Europe is "integrated" in several ways: it has a monolithic, long-lived sponsor and an extremely stable research community. That sponsor (the Commission) considers standards a high priority as it has the authority to mandate their use. Most of the research community resides in on-going organizations with strong industrial engineering influence and which perform "applied research" to solve real problems for industrial firms.

The result is that the European definition of virtual enterprise or organization tends to reflect immediate business conditions; their solutions are evolutionary and practical deriving from existing process modeling methods. They target standards. Slow, steady progress results within a large, sponsored base.

In the past decade, the U. S. government has deliberately not sponsored such work as a result of a quite different political philosophy that puts industry in charge. Standards cannot be mandated or even aggressively promoted. This means that though the research community in North America is probably larger, it is highly distributed, always at risk and often under pressure to create revolutions. The "applied research" part of this community in the U. S. are consultants (who do no actual research or course), while the major research universities tend to focus on more theoretical issues.

Members of the U. S. infrastructure community come from a wider pool of disciplines, including management science – which until recently was unique to the U. S. – together with non-industrial engineering-based perspectives. Network (telecom and internet) related mathematicians are often involved, as well as the huge pool of reconstructed groups in artificial intelligence.

Three examples may illustrate the difference.

The relationship between software engineering and enterprise engineering is murky and confusing. The mainstream of each employs the same general notions of modeling, notation and integration. For practical reasons, Europeans tend to conflate the actual methods of the two, merging application and model integration. Americans have spent more time on a different nexus between enterprise and computer sciences: the thorny issues of knowledge representation and semantic integration.

This can be seen in differing approaches to a standard for enterprise modeling semantics. The U. S. has a small effort toward the Process Specification Language (http://www.nist.gov/psl). This is an exotic, difficult to use, highly formal approach that shows promise to empower whole new ways of doing business. Europe has a significantly larger effort in the same area, the Unified Enterprise Modeling Language (http://www.ueml.org). It leverages existing tools, is decidedly informal, adopts many methods from the software engineering community and addresses immediate business needs.

Definitions of "virtual enterprises" tend to differ geographically as well. The U. S. usually speaks of highly opportunistic, self-organizing aggregations of strangers whose strength is in odd, unexpected skills and whose internal processes, even expertise, will be changed based on collaborative affiliation. These could evolve a product from available processes through emergent simulations (Goranson 1997). Europe's "virtual organizations" tend to be light associations of existing small businesses performing electronic commerce with little dynamic adaptation, derived from a preexisting product or service definition.

The bottom line is that each approach has notable strengths which complement the other well. The European approach has the advantage of long-lived foci, a much stronger stable body of experts and advanced practitioners with established pipelines to standards and users. The U. S. situation is more intellectually rough and tumble involving many shared and shifting disciplines, much more adventuresome goals, and with a longer range, more theoretical perspective.

Below, we report on two areas of research that consistently differ from those of our European colleagues, involving "meta-modeling" and "softness." These are not exclusive of course: U. S. researchers generally agree with, in fact rely on, the European agenda.

3. META-MODELING

Virtual enterprises by definition do all the same work as static enterprises when it comes to processes associated with the actual product or service. These concern tasks that map directly to enterprise rewards and consist of such things as design, fabrication, logistics, sales and support. Ordinary, two-layer process models abstract these processes quite well. But there are a few types of processes that one could loosely characterize as meta-processes that also comprise the work of the enterprise. These are processes that work on other processes instead of the product or service. A simple example is a management process whose goals target the optimization of an assembly process. Such a meta-process actually works on the model of the assembly process rather than the process itself. In fact, the design of the assembly process model is often exclusively geared to support this meta-process.

All of a sudden, the abstraction requirements get very complicated. By actual survey, most enterprises of all kinds have more than half of all their processes in meta-processes of some type. This can range from 50% to 88% by actual count, up to 92% when measured by resources and costs (with a median of 71%). By less scientific means, experience indicates that essentially all virtual enterprise failures and problems are a result of inadequate meta-process (rather than process) modeling and integration.

These meta-processes are of several types, briefly listed below.

3.1 Semantic Meta-Processes

All interesting enterprises use models created using different methods, degrees of formality and explicitness, different extents of correctness, fidelity and aptness, different granularities and often-different ontologies. This is a simple fact in the real world, predating formal modeling and infrastructure frameworks but brought to new heights of complexity in the modern environment. The recognition of such problems and dealing with them are often embedded in other processes and when modeled get left out. Virtual enterprises, especially unplanned, opportunistic, first-time affiliations are severely restricted by a lack of ability to model these meta-processes. Mergers and acquisitions are similarly hampered.

The U. S. National Institute of Standards and Technology is beginning a novel program to address this requirement for meta-abstraction by attempting to define (and standardize) a meta-abstraction feature to capture the notion of "semantic distance."

Here we have very clear example of the differences between U. S. and European approaches. Consistently, in ICEIMT workshops for years, North American representatives have lobbied for an approach to semantics that is generative rather than merely translative. These researchers would move some of the analytic focus to a new level, that of the semantics.

The contrasting "European" position is that the analytic focus should remain on the process itself (and its model). Semantic models and techniques should come into play only temporarily and when absolutely necessary, for translation and possibly verification. The difference in position is rather profound, reaching nearly religious proportions.

This researcher has presented the case for a partially elevated focus in countless European conferences, in private meetings with Commission project managers and industry sponsors, and indeed at a ThinkCreative workshop. Where the idea seems natural in North American contexts, it elicits constant resistance in European venues.

As a result, we have American-led explorations in establishing a new level of semantic focus, currently in the explorations of "semantic distance" standards and formal methods as embodied by PSL. This is risky territory, with many unknowns but potential massive breakthroughs.

And on the other hand we have the aforementioned larger effort sponsored by the Commission to develop pragmatic methods to map modeling methods one to the other. This also uses semantic methods, and is also sophisticated. But it keeps the focus on the models themselves rather than their semantics.

3.2 Monitoring Meta-Processes

As noted, there is a class of processes that work on processes. Obvious examples are management and engineering processes. The features these processes address are the abstractions of the target models. But often those features themselves are the result of other processes; for example, management processes often work on abstractions resulting from a measurement process. In other words, one commonly finds a primary work process (say assembly) that is the target of a metrification process (say an activity-based costing accounting process) that produces its own meta-model, and the assembly management process works with abstractions from both the assembly and the accounting model. To complicate things, another manager (or even the same one) may be working with abstractions from other measurement processes: quality, throughput, workforce fatigue and environmental liabilities, for example.

Worse, these meta-processes include some that are of fundamentally different types. The actual process of modeling is itself a modelable meta-process. The process of learning in the context of the stew of processes and their meta-processes involves a whole class of abstractions of a different type which one usually associates with adaptive systems and emergent behavior. Add to this meta-processes concerned with predicting and engineered adaptation and you have a highly complex lace of processes which are highly interdependent and have many overlays of meta-relationship (sometimes both ways). Abstractions in many models are abstracted from abstractions in others.

3.3 Multilevel Meta-Processes

All that is bad enough, but there is another class of meta-relationships, with a different type of relationship between the features abstracted in a model and the meta-abstractions of a related model. This is the problem of enterprise levels. A typical enterprise consists of several levels of collaborative processes at different levels of granularity. If the system is seen as a self-organizing system – as are many virtual enterprises – then some type of "bottom-up" emergent behavior will be at work. The "bottom" in this case is all of the processes and meta-processes that form the fabric of the enterprise as previously noted. Most of those processes are contextualized at the level of granularity of the processes. That is, a collection of

assembly processes self-optimize in the context of the community of other such processes, using a two-layer framework.

(Here, we use the term "layer" to mean degrees or meta-relationships of abstraction, and "level" to denote hierarchies in the enterprise.)

So we will have an emergent system where the basic unit is the process. Another level exists where workgroups or cells are the basic unit, or agent. Yet higher levels may exist of profit centers, firms and virtual enterprises. At each level, the unit acts selfishly to optimize the whole, at least nominally. Clearly, information moves from one level to the next. Just as clearly, the abstractions at different levels aren't the same. An extreme example might be the prominence of group dynamics at the level of a five-person team, and a similar prominence of corporate culture at the level of the firm.

There is some meta abstraction that occurs here, only part of which is in the measurement meta-processes previously noted. There is in fact, some layering of abstractions that mirrors the difference in collaborative semantics at different enterprise levels. This problem has an analogy in general studies of emergent behavior in natural systems where the semantics of interaction among elementary particles clearly influences chemical "collaboration" but uses different abstractions. The levels in that case step up through cells, organisms, and societies.

3.4 Differing Causal Dynamics

On top of it all, we have an even more vexing problem. A typical enterprise is a collection of often warring infrastructures: one or more each for different communities of interest; activity (including production), design, legal, accounting (what happened monetarily via arithmetic), and finance (what will happen monetarily via probability) are major examples. Each of these has "home territory" in the enterprise. Most infrastructures project their abstractions throughout the entire enterprise in order to optimize the system per their ontology. Users who inhabit each of these semantic universes translate features in the others into their own using a manner of meta-abstraction different than noted above (with the exception of significant overlap between the accounting universe and the "measuring" meta-process of Section 2.2).

Each world has different ontologies, but their difference goes beyond ontological mismatch, at least by the ordinary use of ontology. (The Process Specification Language is theoretically capable of spanning these differences but current sponsors are not interested in this problem.) Their world dynamics differ, sometimes in jarring ways. For instance, in the accounting world something exists only if it can be enumerated. In the legal world, "truth" is a relative matter having to do with admissibility rules. In the product world, features can be annotated to something physical, whereas features in the process are metaphysical.

An average manager has numerous stories about some stupidity from one of these worlds caused by an inadequacy in their abstractions. Each of these worlds situates the system context by different rules, even different logics. Any truly self-aware infrastructure must recognize and accommodate these multiply directed concurrent meta-abstractions.

4. THE COMPLICATION OF "SOFTNESS"

So we have several types of multi-layered abstraction, none of which are well satisfied with the two-layered default of process modeling and current integration frameworks. But there is another set of problems that complicate the puzzle: softness. We make the briefest mention here of the major problems:

No model will have its system context completely modeled. That is partly a matter of economy (why model the entire world to deal with one element of it), partly one of privacy (partners will not reveal all) and partly one of ignorance (some elements and dynamics, especially social dynamics, are not feasibly modelable). Many of these systems have significant components, certainly concerning the larger economy that are non-deterministic.

Another matter of "softness" is the intuitiveness of the models. In the process world, the process and its model are often conflated; in the product world, modelers have a very strong visual metaphor that binds the process and the model; in the financial world, the abstractions of the model have become "real." In each of these worlds, at the two-layer abstraction level it is possible for a practitioner to be an expert in the discipline that the enterprise values and at the same time comprehend the mechanics of the model and its abstractions well enough. Not so with meta-models. So quite apart from the need for new meta-abstraction tools, and independent of the management of complexity, we have the problem of intuitive access.

5. CONCLUSION

Both meta-models and softness have been contentious issues in trans-Atlantic planning workshops. The "customers" for European virtual organizations are not yet asking for meta-model support, and even partial support of "softness"demands nothing less than the reinvention of logic (Barwise 1987, Barwise and Seligman 1997). Yet, this reporter believes that any meaningful progress in the area, however defined, will inexorably face these issues.

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HUMAN, SOCIETAL, AND ORGANIZATIONAL ASPECTS

OVERVIEW

This part presents the socio-organizational issues and the research challenges involved in collaborative networked organizations. The set of contributed chapters included here, mostly focus on the human-related issues, namely, the human-based collaborative networks and the interactions between humans and networked organizations.

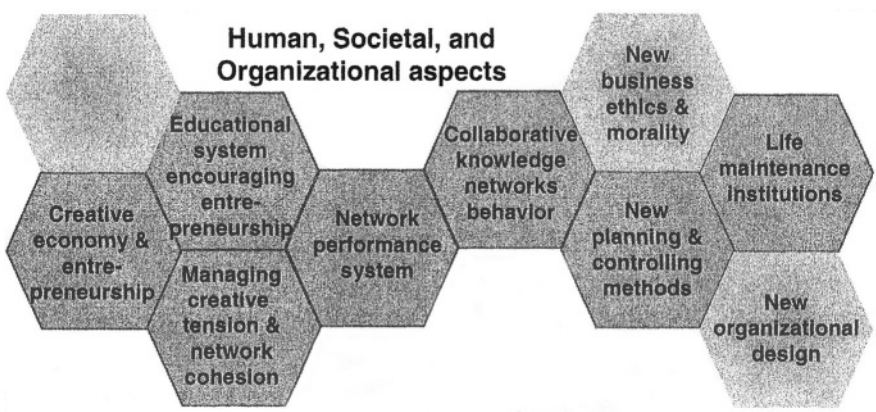
The first chapter discusses the context of creative economy and the importance of new ideas as the source of value creation, analyzing the positioning of human in this context and the challenges he/she faces, mostly as a consequence of the continued erosion of the life stability.

The second chapter outlines the nature of strategic management in the context of collaborative networks, and stresses the need for development of new management approaches.

The third chapter is focused on addressing the social characteristics of collaboration, namely the cross-organizational collaboration between individuals, i.e. interactions between professional virtual organizations and other kinds of virtual organizations, introducing the collaborative knowledge networks.

The forth chapter addresses the need for tailored performance measurement tools for network organizations in order for such organizations to show their superiority over the traditional methods, when meeting the same objectives.

The last chapter thoroughly discusses the issues of business ethics and morality in collaborative networks. After an extensive discussion of both traditional and current trends and attempts to understand business ethics and morality, a research agenda to properly address current challenges in this area is proposed.


Human, Societal, and Organizational aspects
Educational system encouraging entre-preneurship
Creative economy & entre-preneurship
Managing creative tension & network cohesion
Network performance system
Collaborative knowledge networks behavior
New business ethics & morality
New planning & controlling methods
Life maintenance institutions
New organizational design

Some of the main ideas conveyed in this section include:

- To encourage the entrepreneurship attitude required in the creative economy, the society should encourage risk taking while supporting the entrepreneurs, through the development of "life maintenance institutions" and new mechanisms to promote a greater degree of corporate social responsibility. Furthermore, the educational systems need to be designed in the direction of encouraging entrepreneurship, by providing the necessary skills and initiating positive attitude towards the change and organization evolution.
- Methods and approaches must be defined and developed to capitalize upon the "creative tension" in multi-party networks, while assuring the network cohesion and alignment with its objectives. A collaborative network, being an evolving structure, necessities a high degree of discussion and negotiation that combined with the network's problem solving potential, itself creates a context for creativity.
- More experimental results are necessary to be performed, in order to elaborate new methods for planning and for controlling the organization performance, from which also new organizational design and leadership forms can be derived.
- There is a need for understanding and supporting the behavior of collaborative knowledge networks along their life cycle, as well as identification of principles of efficiency, namely in terms of information / knowledge exchange, coordination approaches, and evolution mechanisms.
- Designing a performance system for the network, that can adequately suit both the network objectives and the aims of its members, is an urgent requirement in order to show the added value and superiority of collaborative networks over other traditional business forms.
- The business ethics and morality is an emergent property of CNOs. Complexity theories offer some approaches that seem applicable for developing an understanding of these issues in CNOs. In particular the concept of hypernorm is promising for describing these aspects of the CNOs.

The recommendations suggested in this paper clearly show that the wide implantation of the CNO paradigm is multidisciplinary and not only a technical issue, hence also requiring an integrated socio-organizational research action.

SOCIO-ORGANISATIONAL CHALLENGES IN THE CREATIVE ECONOMY

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The following chapter explores some of the key socio-organisational challenges arising as a result of the emerging creative economy. It is clear that at the outset of the 21st century, the basis for value creation is shifting from tangible to intangible assets. The ability to generate new innovative ideas with respect to product and business process is the key success factor. In order to realize the full potential of doing business in the creative economy, it is necessary to review the impact and implications for society, and the organizations and individuals which give it definition. This chapter tries to consider the key challenges involved and provides some recommendations for concentration now and in the immediate future.

1. INTRODUCTION

The creative economy [1] is an emerging phenomenon, where ideas are replacing the traditional balance sheet assets, as a source of value creation. The ability to generate new innovative ideas with respect to meeting the demands of the market is the key success factor [2]. It is not just a question of product innovation but the key success factor progressively lies in business model innovation [3]. Traditional industries are having to rethink the way they do business. It is not surprising that in 2001, the number of patent applications registered by EU Member States increased by 68.3% compared with those registered in 1996. The trend in the number of people employed in knowledge intensive services continues to grow, accounting for 32.9% of Europe's total employment in 2001 [4].

In the creative economy, the foundation for value creation is no longer primarily focused on tangible, measurable assets. For unlike traditional organisations, the machines of the industrial age, organisations in the creative economy create value by leveraging the power of "intangible resources" such as information/knowledge, brands and collaborative relationships, to identify and exploit new opportunities [5].

Arising in part, as a result of advances in network technologies, the creative economy necessitates a new set of rules and values which determine the behaviour

of its actors. These actors can be distinguished as commercial and non-profit organisations as well as other dynamic market players such as individual and corporate consumers [6]. The creative economy offers new and unlimited opportunities for those operating through it. Realising these new opportunities brings new challenges. The organisation in this emerging economic landscape is inter-linked on various levels, on the information infrastructure level (i.e. via intranets), on the organisational level (e.g. by having abandoned the steep hierarchical structures of the past and replaced them by networked cross-functional teams, and on the competencies level (e.g. knowledge networking) [7].

The trend towards virtual collaborative scenarios gives rise to a blurring of organisational boundaries. For many organisations, strategic partnerships have become central to competitive success in fast changing global environments. Since many of the skills and resources essential to an organisation's capabilities lie outside its boundaries, and as such, outside management's direct control, collaborations are no longer considered an option, but a necessity.

Moreover, the uncertain and fast-changing environment of the creative economy requires new organisational abilities and competencies. Competitive advantage is derived from organisational adaptability, rather than organisational efficiency. The impact on socio-organisational behaviour and management patterns is far reaching. Let us now consider some of the key challenges facing society at large, and the organisations and individuals who give it definition.

2. SOCIETAL CHALLENGES

So how will the creative economy provide for society as a whole? Fundamental business principles of supply and demand, of quality and cost, of trust and loyalty will not disappear. The products and services that emanate from the new economy must fulfil the needs of society, stimulate the development of organisation, and engage the individual. How will organisations and individuals within the new economy achieve this and what barriers are there to this objective? Furthermore, what role will society play in relation to the various players within this new economic environment? What will society look like within the creative economy?

To begin with, we must believe that the changes that are taking place now are stimulated by a need or a demand for such change. As consumers, we are becoming increasingly demanding with respect to the products and services we need to fulfil our wants and desires. In the new economic landscape new dynamic organisational forms will be able to offer a much greater range of products and services. The flexibility of working practices – the 'buy-in' of specific skills – and the adoption of technologies allowing organisations to become virtual, will enable greater customisation of products and services, at a greater speed and at a much reduced cost. Above all else, this will deliver wider choice. In addition, if ideas are the new currency, innovation will flourish. The technological revolution of the 20^{th} century, which had such a profound effect on the way society behaves, will become eclipsed by an ideas revolution in the 21^{st} century.

However, we must keep a degree of perspective. A wider range of choice may be desirable and innovation to be given stimulus, but society as a whole can be skeptical of both. While no-one would argue that technologies like the television, the

telephone or the personal computer have not become pre-eminent within many progressive societies, consumers can be reticent if presented with too much choice. Developments in technology far exceed societies' usage or acceptance of these developments. We have the technology to embed computers invisibly into our homes and yet the design of the personal computer has not really changed in over a decade. If society is swamped with choice, it may drown.

The relationship between corporations and society has always been partially about trust. New forms of organisation, which will be characterised by their dynamism and temporary nature, may find it difficult to establish and maintain the kind of brand strength and awareness so important in current commercial life. In the same way that workers have become used to being part of large production entities (corporations) so consumers have become used to buying goods and services from the same type of organisations. If a technology driven virtual organisation produces high quality, competitively priced product, it will still have to compete with established brands regardless of the quality of its product. Society puts its faith in products it believes in, rather than products that are necessarily the best. In the creative economy, this will be a key gauntlet that society will throw down.

One way of the organisation continuing to thrive in a culture increasingly dominated by the individual will be to align itself more closely to society, or more specifically, to communities. The increasing importance of corporate social responsibility is a reflection of the corporate's need to find itself a new place, or at least a different vantage point, within society. Inherent in the traditional organisation is the notion of bringing people together. This notion is becoming less and less relevant in terms of the production of goods and services. However, we all still live in communities where we have a shared culture and a need for collective social responsibility. As governments become less involved in directly funding or supporting social projects, it may be that society will begin to develop a very different relationship with organisations, one which goes far beyond the simple provision of goods and services. Organisation as benefactor, nurturer and provider may seem contrary to capitalist principles, but this may become one of the most effective ways of keeping the brand alive.

The make-up of our society is also likely to change as a result of new emerging forms of organisation. This shift is already happening: where it was once true that urban conurbations expanded to accommodate the rising workforce, the opposite is now the case. It is no longer necessary in many creative economy jobs to inhabit a specific physical space in order to perform your day-to-day functions. Information and communication technologies, as well as the nature of the work many people now do, has rendered the centralised office space at least partially redundant. While many of us still travel to an office site every day, many people could do the same job anywhere on the planet, given the right technology and the right communication tools. 'Remote working', as it's sometimes called, has been with us for some time and is a growing phenomenon. For society, this means that where we live is considerably less dictated by where our job is. In fact, the whole notion of a company being 'based' somewhere will become outdated. Organisations will exist in virtual space. Thus, so can the individuals who work there. This fundamental decentralisation of workspaces will lead to a much greater degree of flexibility in relation to the movement of people. Communities will become more multi-cultural. Individuals will be able to move country without moving jobs. The movement of

people between communities, between societies, will create an entirely new cultural landscape. This trend will in turn, feed the further development of the creative economy.

3. KEY IMPLICATIONS FOR ORGANISATIONAL BEHAVIOUR

To understand some of the key implications for organisational behaviour it is interesting to compare the characteristics of the more traditional organisation with those of the organisation in the creative economy. The traditional organisation, and the way it behaves, is driven by following key characteristics [8]:

- A reliance on a distinctive hierarchical structure to support the coordination of tasks. Such structures tend to encourage the pursuit of individual interest rather than mutual benefit which stifles creativity and innovation.
- Roles are clearly defined and the boundaries of responsibility clearly drawn in order to improve efficiency. Task specialisation and differentiation may lead to efficiency improvement in the short term but differentiation gives rise to demarcation which in turn inevitable leads to conflict among actors who ignore organisational objectives in favour of self interest.
- Management is concerned specifically with organising, planning and controlling. Organisational boundaries must be preserved to retain the power necessary to preserve position and status;
- There is an emphasis on vertical interactions. Decisions are taken at the top and passed on down the line. As a result, individuals within the organisation lack a sense of ownership and commitment to organisational objectives is problematic.
- A high value is attributed to local knowledge, experience and skill. Geographical constraints have an important influence in determining where the organisation is located.
- Members of an organisation sell their time rather than their competencies and are expected to pledge loyalty to the organisation and its management.
- The external environment is relatively stable and emphasis is placed on the need to organise and control rather than to motivate and mobilise for change.

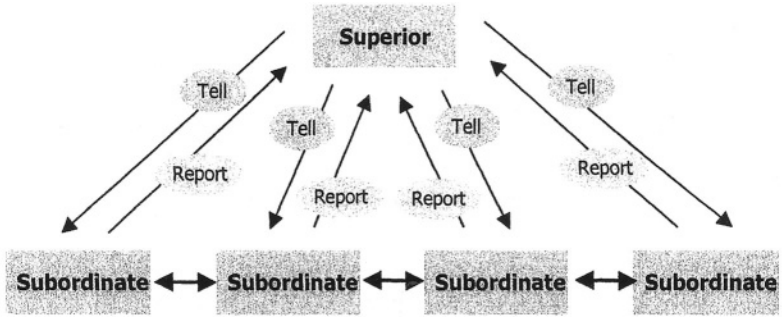

Figure 1 - Relationship structure in the traditional organisation

Although as yet far from obsolete, the traditional organisational structure does not lend itself well to the demands of the creative economy. The creative organisation derives its success from a different set of characteristics. The creative organisation, and the way it behaves, is driven by the following key characteristics:

- The need for a continuous reassessment of tasks and assignments through interaction with others – organisational performance is improved through an iterative process whereby the organisation moves up the learning curve, through "learning by doing";
- A network of authority, control and communication based on expertise and commitment to the overall task rather than on clearly defined roles – since the task must be constantly open to revision;
- Tendency for communications to be much more extensive and open – a characteristic inevitable in an environment where the free flow of information throughout the organisation is uninhibited;
- Communication style and pattern that is both lateral and diagonal as well as vertical – the organisation becomes a network both internally and externally;
- Greater emphasis on commitment to the organisation's tasks, progress and growth than on obedience and loyalty – as decision making power is placed in the hands of individuals who are best positioned to rise to the challenges facing the organisation, a greater sense of community and ownership is generated. The individual realises that he/she is a stakeholder in the organisation;
- High value placed on expertise relevant to the technological and commercial milieu of the organisation – as a result of the need to focus organisational resources and competencies on core activities;
- Leadership style with emphasis on consultation, interpersonal and group processes – in an environment subject to constant change, emphasis is placed on establishing direction, aligning, motivating and inspiring people.

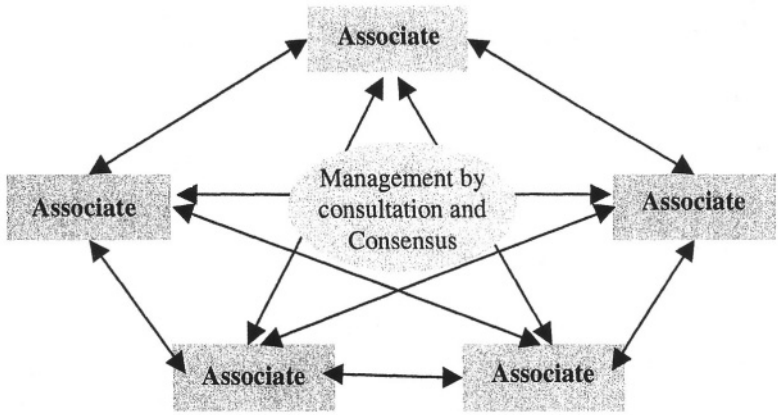

Figure 2 - Relationship structure in a creative organisation

Organisations in the creative economy are communities of partners, or associates, who share a vested interest and common purpose [9]. They depend on human

interaction, individuals sharing information and experience, something that is only possible where there is a high level of trust [10].

Organisations in the network age, unlike those of the industrial age, will not seek to control their environments but recognise that any such attempt would at best, fail, and at worst, stifle the creativity and imagination necessary to support innovation. In the creative economy, markets are global and participants are free to focus and re-focus their commitment as they see fit. With this in mind, management style is evolving from one, which placed emphasis on planning, organising and controlling, to one, which emphasises providing vision, motivating and inspiring [11].

4. CHALLENGES FOR THE INDIVIDUAL

In the creative economy intellectual productivity is the new currency. This shift, already underway in many industries, will see a fundamental change that affects every working person: the empowerment of the individual. While this empowerment throws up some challenges, this new economic environment will be one in which personal opportunity is boundless and the idea is prized above all else.

The post-industrial landscape has mastered the art of production – we are so efficient in producing physical product that we have a workforce increasingly employed in the provision of services and abstract goods (software; advertising; entertainment etc.) [12] Within these industries, it is the idea that generates wealth and stimulates growth. Consequently, it is the people, and not the machinery or the processes that represent the value and the future of the new organisation. Individual employees become unique and, in some cases, irreplaceable assets. We each become our own company. Where before we were limited by the constraints of the organisational machine, by the labels imposed on us by rigid corporate structuralism, we are now limited only by our imagination. And we are empowered by the simple truth that the organisation needs us, and not the reverse.

But with the power comes responsibility. The creative economy may offer a vast plain of opportunity, but it could get a bit lonely out there. Old economy corporations are the wise grandfathers of our working lives: they provide us with a framework, a structure, often a physical space and a strategy to work to and within. All this will change in the creative economy. The stability once taken for granted by a large proportion of the workforce has been gradually eroded over the last two decades. This process will continue apace: contracts will be shorter; the organisation itself will be less tangible both in a physical and a strategic sense. As the power of the corporation increases, so the responsibility to manage personal development falls onto the individual. Education and training develop talent and is the key to unlocking ideas and creativity. It will be down to the individual to manage this part of their working life. The individual will also have to become increasingly entrepreneurial. In a career profile that may demand a wide range of skills, will involve working with a continually changing roster of teams, often distributed or virtual, and the individual that can adapt and react will prosper.

The flexibility both accorded by, and demanded of, the creative economy has two sides for the individual. On the one hand, one can read flexibility as freedom [13] a career in the creative economy will take in many more phases, will involve a change in roles from project to project, rather than from job to job, and this will

arguably add up to a more fulfilling work life. The idea of a 'portfolio career' has been with us for some time – we are multi-skilled individuals with a desire to constantly expand our horizons [14]. Why should we be chained to a myopic corporate vision of career development? However, flexibility and freedom can generate a feeling of instability, a sense of not 'knowing where you are'. In early industrial economies, workers had a 'trade', a skill they learnt from an expert that defined their place in society. A narrow view of working life perhaps, but one in which individuals could have confidence in their own abilities and where their contribution to the organisation or to society was clearly delineated and recognised. Latterly, the traditional organisation or corporation gave the individual a sense of belonging: many companies have attempted to foster the image of being a 'family', co-supportive, encouraging and supportive. The corporation could set goals against one's aspirations; the corporation would make all those difficult business decisions, the corporation would look after you in your old age. In the age of the individual, there will still be a role for the corporation or for the traditional organisation, but ownership and responsibility will rest increasingly with the worker [15]. It is likely that new organisational structures will reflect this trend. It is a brave new world indeed but one which will ask serious questions of the individual.

It is the choice of the individual whether to embrace this new freedom – how we look at ourselves will govern how others look at us. By grasping the initiative and having the confidence of our own convictions, the individual will become the dominant power in the creative economy. It will certainly be the case that new structures and new types of organisations will develop to reflect this shift in emphasis. The ability of existing organisations to change in order to meet the needs of the individual will govern whether they have any place in the emerging creative economy.

5. CONCLUSIONS

Looking to the future, if we are to derive the full benefits of the creative economy, society's attitudes to risk-taking and failure must change [16]. To encourage an entrepreneurial mindset, society must do more to encourage and reward risk-taking.

To offset the possible negative impact of ever widening choice, technological development must be consumer driven rather than technological development for its own sake.

In order to build trust and support the establishment of brand, systems of quality assurance, as stamps of approval, should be further developed and promoted. As part of the process consideration must be given to promoting a greater degree of corporate social responsibility. Technologies are necessary to support the assessment, measurement and maintenance of standards of acceptable corporate behaviour.

There is a need to improve the performance of communication systems that allow people to work together in real time regardless of location. The concept of learning organisation must be further promoted and developed.

With the rise in remote working practices, continuing support must be given to facilitate mobility and the transfer of skills between regions. Educational systems must be designed to encourage entrepreneurship and a positive attitude to change

whilst more investment should be made in providing people with the means to adapt their skill base to the changing needs of the market.

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TOWARDS STRATEGIC MANAGEMENT IN COLLABORATIVE NETWORK STRUCTURES

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The following chapter outlines the nature of strategic management in a network context. It shows that new pre-conditions and new perspectives have to be considered to fully understand network processes from a strategy perspective. Due to the multitude of interests Involved, the network's co-evolution is considered to be essentially emergent, based on the results of dialogic processes. As a consequence to these changes, traditional managerial competences will have to be complemented by new network management capabilities. While trying to align network partners and to enhance the network's cohesion, managers must equally capitalize upon the creative friction in the network's structure to exploit its problem-solving potential. However, new networked organizational forms may even sustain without having any high-level governance at all.

1. INTRODUCTION

In the light of on-going change and increasing uncertainty, firms are more than ever concerned with fundamental and far-reaching problems influencing their future development. Rising importance is therefore given to accurate decision-making, to a more conscious consideration of possible futures and an active preparation for emerging issues. If one tries to capture the essence of this behavior, it is especially the strategic thinking that has found its way into the managers' minds.

In these days, an abundance of literature is available on the strategic management of the firm. However, the field of strategic management has never given much importance to the role networks play and the popularity of the majority of strategy approaches increased without taking into account a fundamentally different context. This development is worrying to a certain extent as the organizational structure has always been a major issue in the strategy field. Looking back at the roots of strategic management, it was the "Structure follows Strategy" paradigm itself, stated by Chandler, one of the strategy pioneers, that emphasized the interrelation between a company's structure and its long-term success.

Undeniably, the emergence of networked structures has added a layer of complexity to the strategic management debates (Carpenter/Westphal, 2001). Regarding a company's outward connections simply as a factor in the assessment of external forces doesn't sufficiently reflect the variety of effects resulting from the inclusion in a network. It is therefore recommended to re-consider the 'structure follows strategy' paradigm, as the term 'structure' cannot solely refer to the clearly identifiable structure of a single company anymore, but has to deal with the moving and sometimes fuzzy boundaries of networks.

Within this chapter, we will show that traditional strategy concepts might not work in a network context due to the emergent nature of the network's development. However, we will also show that strategic thinking gains importance since the more networked the context gets, the more managers need to understand the interrelationships in complex networked structures.

2. STRATEGIC MANAGEMENT IN A NETWORK CONTEXT

2.1 The role of emergence in network strategy

The emergence of new organisational forms, and especially the formation of networks, can be regarded as the result of a combination of competence-driven and market-oriented strategies. Networks seem to have the ability to fully exploit the potentials offered by ICT advancements and continue gaining importance in virtually all industrial sectors.

However, only few evidence exists on how these organizational forms, in turn, have an impact on strategic management activities. A wide array of partly contradictory opinions exist regarding the definitions of 'strategy' respectively of 'strategic management' (Feurer/Chaharbaghi, 1995). We consider strategic management to be a bundle of activities enabling the conscious alignment of an organization's ambitions with the internal resources and the external settings it is facing. Recent research suggests that the strategic management of new organizational forms, i.e. loosely coupled systems and information-technology-enabled organizations, exhibits fundamental research weaknesses (Dhillon/Orton, 2001). Apparently, one of the major shortcomings is that strategic management of networks is insufficiently grounded in research on more "traditional" organisational strategies and traditional organisational forms. Existing concepts, e.g. decentralisation approaches, are re-designed and extended to cover the new networking field without taking into account the fundamentally different conditions in a network context, such as their transitional nature (Reiss, 1996). Misunderstandings and opposing opinions in academia as well as among practitioners are the result (Wall, 2000; Scherm/Süss, 2000). Does a company acting in networks need a different approach for strategic management, does the network as such need a clear-cut strategy? Potential attempts to clarify and consolidate advancements in research, especially to describe networks in contrast to the traditional hierarchical company, always run the risk of over-simplification, since uncountable possible constellations of networks exist, creating a fluid spectrum of organizational forms ranging from the 'traditional' hierarchical company to the fully networked and virtual organization.

While strategic management traditionally dealt with strategy concepts on the functional, the business and the corporate level, "collective" inter-organisational strategy concepts haven't been able to reach the same importance yet (Sydow/Ortmann, 2001). Based on the presumption that strategic management in collaborative networks differs significantly from traditional approaches due to the lack of hierarchical structures, an indispensable first step is to get a common understanding of what the nature of strategy is like in the era of collaboration.

In an effort of classifying strategic management literature from the last decades, Mintzberg (1998) identified ten different schools of thought regarding strategy and demonstrated the impact and insights they brought to the strategy community. The most decisive observation for the understanding of network management is that even though strategies are in most cases created in a formal way, they are subject to modifications in the course of time. In almost every case the intended strategy is significantly different from the realized strategy, which questions the applicability of strategy approaches in favour of formal deliberate strategy making, especially the one concerned with 'strategic planning'.

While formal approaches are still useful in various ways and maintained credibility through continuously improving their forecasting techniques, it is the sheer number of participants in networks that leads to a different understanding of strategy formulation. As a multitude of organizations have their stake in the network's evolution, the outcome of a network's long-term development has a strong tendency to be emergent in nature. Emergence is regarded to be the "... process by which patterns or global-level structures arise from interactive local-level processes. This 'structure' or 'pattern' cannot be understood or predicted from the behavior or properties of the component units alone." (Mihata, 1997)

If this presumption is true, strategic management in a networked context gets a significantly different notion. Individual plans constantly interfere with the networks' intentions and while there is still a strategy formulation on the level of the network's individual members, and first approaches exist to institutionalize an 'emergent strategy development' process (Downs/Durant/Carr, 2002), it makes more sense to talk about 'strategy formation' on the network level. To illustrate the new presumptions one must consider, it is useful to have a look at the traditional strategy-making process and examine its applicability in a network context.

2.2 Understanding strategy formation in networks

From a process view, strategy related activities can be ordered in a specific sequence. Usually these activities include goal setting, strategic analysis, strategy formulation, strategy implementation and strategic control. In a continuous loop, companies run through this cycle and even though in practice these stages are formalized to different extents, these activities are to some extent found in almost all organizations.

The strategy development cycle can be considered as complex problem-solving task. Individuals decompose problems into sub-problems, apply dedicated solution methods to it and assemble the results into a high-level solution. However, the traditional way of developing strategies gives rise to significant problems in a network context. As network boundaries are blurry and continuously change,

strategy processes cannot be simply executed with the legitimating force of the hierarchical system. Instead, executing strategy processes in a network context requires the consideration of new pre-conditions (Sydow/Windeler 1999).

1.) Decentralization and volatility of decisions, communication and resources
As networks deal with strategy processes, the conditions for doing so are far more difficult compared to former times. As resources, interests, power and decisions competency are decentralized, fluid and changing over time, the management challenges continue to rise. While it is usually the stable times that give an organization the opportunity to exploit its capabilities in a profitable way, a network is usually perpetually in motion. For dealing effectively with this restraint, the network should develop the capability of networked thinking, i.e. taking into account multiple cause-effect relationships to estimate the results of one's decisions.

2.) Inconsistency of interests
Even though the reason for joining a network is usually based on the willingness to cooperate and to achieve a common goal, the sum of all members' goals will always be a broad array of diverse interests. To exploit the full network potential, it is necessary for the companies to find a minimum goal overlap and to ensure a balance between competitive and cooperative interests.

3.) Novelty of coordination principles
The conditions for network management differ so much from the current situation in traditional companies, they can hardly be understood, explained and managed with conventional methods. As a result, it is up to the network to manage internal and external requirements and to develop new mechanisms for one's configuration.

A network has a living structure and is in constant movement. Trying to manage the network connections down to a detailed level would imply overriding the problem-solving capacity of its members and may lead to a paralyzed structure. Each network partner reserves the right to participate in strategy processes, hence decision-making shifts from a predominantly top-down approach to a collaborative approach. Within this approach, the strategy processes reflect the outcome of discussions and negotiations., therefore strategy-making will include a distinctly dialogic dimension (Lambrechts/Sips, 2002). Such a procedure, however, may lead to mediocre results and is relatively time-consuming. To ensure the exploitation of the network's problem solving potential, the whole network and its members must have the capabilities to self-regulate, to leverage their activities and to evolve over time in a mutually fertilizing way. Consequently, network management is especially characterized by managing friction, dilemmas and tensions.

2.3 Getting the most out of strategy formation in networks

If the process of network evolution is hardly predictable, it has to be assured that negotiation processes capitalize upon the diversity of individual strategies. As networks are constructed around social linkages, it is useful to benefit from the insights originating from social studies. An interesting classification of planning approaches comes from research on policy making, where the basic challenge

consists of coping with a large variety of interests and of finding solutions that are capable of satisfying the majority of concerned stakeholders. Innes and Booher (2000) present four models of planning and policy making according to their ability to deal with different degrees of diversity of interests as well as with different degrees of interdependence between interests (figure 1).

In the so-called 'technical bureaucratic model', there is neither diversity nor interdependence among interests. This situation is relatively easy to handle, as the risk of conflict is low. A careful analysis about the right course of action will convince players of the right way to opt for in the future. The opposing model of planning is the one of 'collaboration'. In this case, the diversity of interests as well as their interdependence is high. Stakeholders continuously co-evolve to a common understanding, direction and set of heuristics. This model does not try to override individual interests, but includes them simultaneously and creates broadly accepted solutions. Despite the risks of this planning approach and its often tedious and time-consuming procedures, Innes and Booher claim they are the only way to address complex and controversial issues.

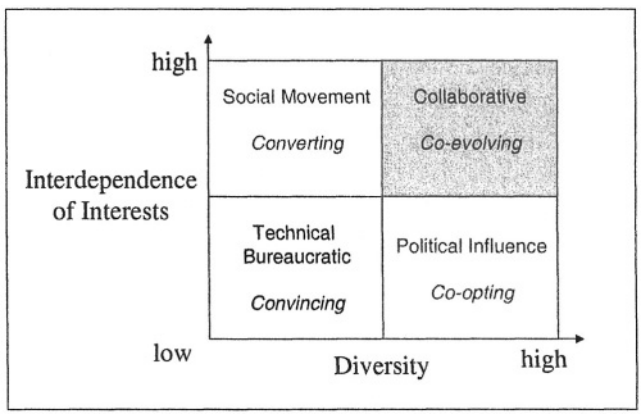

Figure 1 – Four Models of Planning and Policy Making (Innes/Booher, 2000)

Although this model explains the desirable nature of effective collaborative decision-making, the pre-requisites for successful co-evolution still remain unclear. From a technical perspective, ICT seems to enable organizations to technically set up collaborative networks, but the integration of the 'soft' perspective remains an open question, which is somehow worrying, since, as we found out, it is especially human interaction and negotiation that gains importance from a strategic point of view.

People are the core constructs of networks and the human perspective has its distinct influence on collaboration. In fact, factors such as trust and identity are crucial for network performance (Lambrechts/Sips, 2002). The transitional and blurry nature of networks itself, however, is an obstacle for collaboration. Stabilizing forces therefore remain a pre-requisite for interaction within networks and constitute an integral success factor. For instance, the existence of trust in temporary networks is an important facilitator, yet its gradual development through

collaboration, dialogues, negotiations etc. will never be achieved in a way similar to traditional organizations. In addition, the creation of a network identity plays an important role for a network's success. If members do not identify themselves with the network, it is likely that their motivation for engaging in the network's well-being is limited. Especially in times of crisis, this missing commitment could lead to the dissolution of the whole network, which, in turn, would have a negative influence on its members in the long run. It seems that the need for trust and identification is prevailing and special forms of trust, e.g. 'swift' trust (Iacono/Weisband, 1997), and identification, e.g. with the aid of organizational metaphors (Morgan, 1986), will substitute respectively complement these human-related requirements. Managers trying to get the most out of the network should incorporate these mechanisms in their thinking.

The last paragraphs have shown that the functioning of networks depends on a variety of factors, which are demanding for the individuals and organizations involved. However, the emergence of collaborative networks is ongoing and rising, often without even considering any potential management problems and their implications. Innes and Booher (2003) contend that the sheer possibility of collaboration will create its own 'institutions'. These institutions are not determined in terms of shapes and size, yet they have common characteristics: they are fluid, networked, evolving, involving dialogue and distributed intelligence (see Linux case). Talking about institutions clearly extends the traditional comprehension of organizations, reducing today's traditional and mainly profit-oriented organizations to just one of many different organizational forms. Accordingly, new and more appropriate approaches to strategy formation will appear (e.g. purpose-based strategies (Kemp/van Wendel de Joode, 2002).

The Linux Community (adapted from Kemp/van Wendel de Joode, 2002)

The Linux community is a perfect example of a new emerging collaborative network linked by ICT. Linus Torvalds created the Linux kernel in 1991 (Wayner, 2000), when being a student. At that time it could only perform some really simple tasks. He decided to put the source code of the kernel on the Internet, asking what others thought of his creation. Ten people downloaded the source code and five of them send him a response, in which they added bug fixes, code improvements and new features (Naughton, 1999). Linus reacted on every response and included most of the fixes and improvements to the kernel. After every change he released a new version on the Internet, which in turn lead to new responses.

Today, the network consists of thousands of highly skilled professionals from all over the world contributing to the elaboration of the Linux operating system. None of the individuals has the knowledge, skills, power or resources to develop a complex product like an operating system by him or herself. Instead they have to collaborate with other professionals, who can provide the knowledge and skills they lack themselves.

The low boundaries to enter and exit Linux create a very dynamic and rapidly changing community. No one has been able to explain how such a dynamic, informal and geographical distributed community can create a reliable and stable

operating system. One might suspect to find the answer in a strong management and the prominent role of Linus Torvalds, the Linux inventor, as a means to ensure coordination and communication between the members and the projects. This is not the case. Some projects have so-called maintainers, but to call them managers is quite overstated.
Communication and coordination between the various projects is even more absent: on a macro-level there is an absolute power vacuum. Even companies investing money and other resources in Linux, have no control over the community as a whole. The character of relationships between the members does not provide an answer either. Most members have a very loose-coupled and rapidly changing relationship with other members. Most of them work relatively independent of each other on the problems they face. Communication between the members is very informal and very often centred around rather specific technological issues. However, the community does have a sophisticated infrastructure, consisting of tools like e-mail, Internet Relay Chat, discussion boards, project tools, File Transfer Protocol, Concurrent Versions Systems etc. to facilitate collaboration.

3. CONCLUSIONS AND IMPLICATIONS FOR FUTURE RESEARCH

The era of networks poses a significant amount of problems as well as prospects for future organizations. ICT has reached critical mass to empower organizations and individuals to share their interests, to easily join forces and to pursue common objectives. From a strategic management perspective, it seems to be of utmost importance to provide holistic approaches to make managers understand the evolution of networks and to overcome the shortcomings of current contributions on network research. Time-consuming longitudinal studies will be necessary to draw conclusions, yet the outcomes of this research are worth the efforts.

Some major issues are:

- Broadly speaking, the most interesting question is how co-evolution on the network level can be supported by strategic management activities.
- Managers need to find ways to capitalize upon the ongoing creative tension within the network while assuring the network cohesion and alignment to provide timely and market-oriented solutions.
- Based on experimental results, also drawn from non-conventional collaborative networks, new methods for planning and controlling, organizational design and leadership can be derived and put at the disposal of practitioners.

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COLLABORATIVE KNOWLEDGE NETWORKS

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This chapter outlines the emergence of collaborative knowledge networks (CKN) as a response to today's business environment. While focusing on the social characteristics of collaboration, basic premises and working principles for cross-organizational collaboration between individuals are presented and subsequently transformed into challenges and recommendations for new forms of organizations. A case study on Skandia's GOLD community illustrates the findings.

1. INTRODUCTION

The pressure to more rapidly adapt the business is driven by the increasing amount of what Davis and Meyer called Blur (Davis and Meyer, 1999). They coined the term "blur" to describe the combined effect of Speed, Connectivity and Intangibles on the business world. Speed is how fast change occurs within the business environment. Connectivity is how networked businesses are becoming to one another to complete a value chain that offers a product or service to the market. Intangibles are the ratio of non-physical to physical assets in the final offer to a consumer. The greater the amount of blur in an economy, the greater the frequency and speed with which companies must adapt to it.

Today all three are increasing tremendously. Thus managers are being forced into an almost constant state of adaptation. It is not surprising that business leaders and management consultants and theorists are looking beyond traditional metaphors (business as machine, business as information processor) and beyond traditional business structures to gain a better understanding of how to respond to this new environment.

An increasing amount of "blur" was one of the reasons if not the reason why intangibles and knowledge management has moved up the business agenda of enterprises throughout Europe. Most of the companies, institutions and authorities find they deal more or less explicitly with the issue. Knowledge management is recognised as being a major driver for company performance.

From the beginning of the 90s, when the knowledge management movement started with works from Sveiby (1997), Davenport and Prussak (1998) and Edvinsson (1997), the focus of knowledge management was very much on identifying, acquiring, sharing, distributing and developing knowledge within the physical boundaries of a company. Very often heavy weight IT infrastructures were built to support those knowledge related activities.

Over the last years an interesting shift of paradigms has been observed: Driven by the evolution of new organizational forms, like networks, communities and partnerships the focus shifted from a more IT centered perspective to a more human centered perspective on KM: People like Wenger (1999), with their community thinking postulated that the process of sharing knowledge needs to be driven by human beings working voluntarily in a community which shares common interests and thoughts. Thus, according to Wenger communities can be described as self-organized and self-directed groups of people, informally bound together by a common mission and passion for a joint enterprise. Collaborative knowledge networks (CKNs) link communities together providing a technical and social infrastructure for collaboration and knowledge management (Deloitte, 2002).

Very often these networks are set up virtually over different locations relying thereby on internet applications giving their communities a home.

Recently, communities and collaborative networks have become a recognized and valuable new type of organizational form. Some of the latest literature (Deloitte, 2002) states that companies which provide such type of environments gain significant benefits in the areas of knowledge transfer, response times and innovation.

This essay outlines some of the basic premises and working principles of these 'Collaborative Knowledge Networks (CKNs)'. Their behavior as a system where individuals (choose to) collaborate across organizations is explored; leading into list of challenges and recommendations for new organizational forms relying on the example of collaborative knowledge networks.

2. COLLABORATIVE KNOWLEDGE NETWORKS FROM AN ECOSYSTEM PERSPECTIVE – *the social characteristics of collaboration in emerging types of organizational forms*

This section discusses the elements of collaborative knowledge networks and emphasises those features that distinguish them from similar organisational forms (such as project teams). This focus on the distinguishing features of collaborative knowledge networks highlights the extra challenges faced by this organisational form. Of course, the typical problems of communication, vision, leadership, efficiency etc apply to most (or all) organisational forms and, as would be expected, equally apply to collaborative knowledge networks.

The ecosystem perspective is used here as a common model to illustrate key features of collaborative knowledge networks. In particular, an ecosystem is made up of apparently successful individual parts which can live and be studied independently; sustainable life however is only possible when the inter-relationships between the (living) parts happen. This metaphor is common in the practitioner

literature on emerging organizations (Hatch, 1997; Grant and Oswick, 1996; Morgan, 1986) and suggests that we can valuably analyze collaborative knowledge networks through seeking to understand how the individual organizations behavior makes the WHOLE system more likely to succeed. Another helpful dimension of the ecosystem metaphor is the lack of legal-contractual relationship between the parts! While obvious, it can help us to reflect on the role of contracts and whether they are useful mainly when a network becomes fixed – for example, when a collaboratively developed product enters mainstream manufacturing – but the network has transformed into a different organizational form at this point!

Collaborative knowledge networks exhibit a number of characteristics when viewed as operational social systems, including:

- Membership is on a voluntary basis. It is relatively easy and convenient for members to join the network. Often simply registration via email is sufficient. There are no expectations with regard to contributions. „Observers“ can also be welcome.
- Volatile Structure; there are no or few „hard“ organizational structures. The whole set-up relies on self-organizing principles and self-control, at least in its formative stages. Often a community manager is the only person with a clearly defined role. She needs to have sound facilitation and moderation capabilities. Experience shows that knowledge networks go through ups and downs as well. Especially while being in the „Valley“ a community manager may try to stimulate and trigger activity.
- Limited life-cycle, the volatile set-up might result in limited life-cycles compared to more traditional organizational structures.
- Membership is cross-functional, cross-boundary, cross-cultural and multi-site. CKNs “ignore” the boundaries of traditional forms such as functional lines, horizontal hierarchies, or legal borders of companies.
- Members share common interests, visions. Due to the fact that participation in CKNs begins on a purely voluntary basis, self-interest is the driving force and motivation to join.
- Innovative, ‘out of the box’, thinking may be a motivation for joining the network. It can be observed that very often out of the box items are discussed within CKNs. People may see in CKNs an island where they can escape from day to day business.
- Very high transparency of information. There are few information and knowledge barriers. “Everything is visible to everyone”.

3. CHALLENGES AND SUCCESS FACTORS FOR IMPLEMENTING NEW FORMS OF COLLABORATION

using CKNs to illustrate emerging collaborative environments

Though the need for knowledge about success factors that support collaborative knowledge networking is high, the availability is generally poor. This may be due to

the lack of real cases that have been researched. There are some relevant insights from those authors who do venture to comment on failure or success factors:

A number of, mainly practitioner, authors have proposed success factors based on the business process engineering or change management school. A typical example comes from Lockheed-Martin (Carpuccio, 2002) who suggests the following elements of success:

- Top management support
- Oriented around a particular venture
- Captured on a 'single sheet of paper'
- Sincere commitment to 'make it happen' at lower levels
- Developed slowly over time
- Technical, design, cost, schedule and cost confidential data shared
- Performance measures in place and taken seriously
- Key decisions discussed and mutually agreed upon
- Continual high level executive communication.

Carpuccio goes on to propose an equation in which *shared vision & financial rewards & mutual trust = successful partnership.* He suggests that if any one ingredient is missing the partnership will be unbalanced.

While these act as useful reminders of success factors they are not usually accompanied by data about how the organizations achieved the factors; or even a precise test of when, for example 'top management commitment' exists.

On the legal side a few success factors emerge (Powers, 2002):

1. the avoidance of joint ownership of Intellectual Property (because it reduces exploitation efforts and/or results in disagreements);
2. if patents are used then ensure that prosecution and enforcement rights are clear (who will pay to enforce the patent);
3. confidentiality agreements are absolutely necessary but must be done non-aggressively to avoid souring final discussions
4. keep the 'deal' written down as a work in progress
5. contracts are tools for litigation not creating partnerships, so should be formalized as a final step.

Ring and Van de Ven (1994) see forming and maintaining new collaborative forms as a repetitive sequence of negotiation, commitment and execution stages, each of which is assessed in terms of efficiency and equity. These stages overlap through recurrent activity and the duration of each stage varies according to the uncertainty of issues involved, the reliance on trust among the parties and the role relationships of the parties

Further success factors are proposed to be:

- Having a joint Performance Measurement System (PMS); at first sight PMS and basic community principles like self-organization may sound contradictory. However experience shows that few but meaningful measures are important to

guide, facilitate, support and improve knowledge sharing and creation within CKNs.

- Maintaining high motivation for newcomers to join the community/CKN. Fresh viewpoints and knowledge are key for a sustainable network. Therefore special emphasis should be put on motivating new people to join.
- Identifying strongly with the community. Effort is made to identify and explain the specifics which make the community unique and valuable.
- Having a trustful environment. With very high transparency of information trust in the other members and their behavior is crucial.
- Having a Community Manager/Facilitator. Although CKNs rely on self-organizing, experience shows that there needs to be someone who ensures the overall health of the community (and not just concentrate on their own selfish benefits – which is rightly, what the members are doing).

Amongst the many observations, the above authors recognize the challenge of 'equity', or the sharing of the benefits of the network. If one member sees another member as benefiting dis-proportionately then that member may leave or stop contributing. With standard (business) relationships the equity is decided by the collaboration initiator (e.g. the customer asks for a supply of goods at a price), the supplier joins in already knowing the approximate equity position. For new organizational forms the shape and purpose can emerge from within, therefore the equity position also emerges and the potential for perceived 'unfairness' is much greater. The authors also helpfully recognize that legal protection is an hindrance to this not a solution.

The speed with which CKNs can form may create the impression that they stabilize very quickly. The authors also point out that excellent collaboration takes time, energy and management attention to develop. This emphasis on management attention comes from the specific collaborations studied – usually inter-company collaborations. More extreme forms, exemplified by the Linux community or Charities, operate almost completely outside of the daily business environment.

Because members may arrive with different personal goals from multiple environments (they may represent themselves, a charity, a profit making company, government etc.) there is a high potential to misunderstand other members' objectives and motivations. Misunderstanding can quickly lead to an under-performing -or even failing- network when one member interprets another members behavior or words incorrectly. This failure to recognize the legitimacy of other members having values that are quite different to your own can be mitigated by "active" sharing of values.

The need for 'trust', 'communication', 'shared vision' and other social behaviors is a common theme among authors. But few have analyzed how they were achieved in successful CKNs. One route is to have a Community Manager/Facilitator with some independence from the members; but this is only available to well-resources collaborative networks. This is a significant gap in our knowledge.

4. RESEARCH TO IMPROVE THE EFFICIENCY AND EFFECTIVENESS OF NEW FORMS OF COLLABORATION

- emphasising social behaviours that impact performance

Based on the above a list of challenges is proposed which can be interpreted also as research recommendations in this domain.

- How to define the different life-cycle phases (from initiation to dissolution) of such networks? And what behaviors (and their supporting IT and management environments) are appropriate to each phase? (e.g. the transition from ad-hoc driven structures to standardized structures to increase operation efficiency).
- What are the characterizing elements of each life cycle phase of the network?
- How does the individual members behavior affect the other members of the network? And how can this be influenced to increase success of the network?
- Membership of CKNs may be by individuals, commercial organizations, charities, government agencies, etc. Due to their different purposes and legal position, collaboration between these can create significant legal difficulties. Yet dealing with those difficulties too soon may result in dissolution of the network through weariness. New ways for assigning and determining Intellectual Property and equity have to be created.
- How do effective CKNs and effective members handle information interchange? Especially information demand peaks, requests for apparently sensitive information, feelings of being the teacher.
- How does a CKN choose between a central "management/control" function and a totally decentralized and "democratic" approach?
- How does the network (re-)configure itself by finding and losing new members, to react to an ever-changing and unpredictable environment?
- How does the interaction between different Collaborative Knowledge Networks affect the behavior of a member who works across multiple networks?

5. THE SKANDIA GOLD CASE

CASE STUDY: Communities of practice, being one special type of CKNs, at Skandia – the GOLD (Global Objective – Local Development) case

Skandia Insurance Company Ltd. is the largest and first insurance group in Scandinavia, dating back to 1855. Today it's a global financial services company with offices in more than 20 countries. Skandia is well known in the knowledge management community, as their Skandia Navigator tool and its implementation is still considered to be a benchmark for Intellectual Capital Management in distributed and knowledge intensive networks.

The GOLD community grew from a continuing series of workshops and presentations by the GOLD team to various Local Business Units (LBU) technology staffs. The team decided the best way to overcome the issues of language and culture was by bringing selected individuals from different LBUs

to Shelton, (Connecticut, USA) to work together for an extended period of time on a GOLD application.

The goal was to make sure the participant had a positive learning experience. They aimed for the LBU participant to return as a GOLD champion. The emphasis is on having the participant understand the GOLD method and how it is implemented. Time is spent teaching the history of the project and its development to the newly arrived participant.

The GOLD team created a physical space in Shelton where the core team and the LBU participants work on a single application. During this process the LBU participants learn the GOLD method and how it's used in an actual development situation. The participants spend 3 to 6 months in Shelton.

When the LBU participant returns home they begin the missionary work of teaching the GOLD solution to the other LBU technologists. But the LBU champion is not left alone. The community has an active web-site where the LBU champion can find white papers and tips posted by other champions or the GOLD team, or she can post her own.

Each permanent GOLD team member is assigned to an LBU with the specific task of visiting that LBU on a periodic basis. This has two purposes. First if there is no LBU champion, the team member can continue the selling process. Second where a champion is present, the GOLD team member can provide advice and information, and further develop the community relationship.

Using a CKN approach to deploy GOLD in Skandia AFS's highly decentralised environment is already showing success. Since being launched in 1999, the community has worked on three applications. It has brought together, and developed, champions from four LBUs (Spain, Colombia, Germany and Mexico). There are now requests from the larger LBUs to send their own staff to become part of the GOLD CKN.

Lessons Learned (according to Skandia)

Don't underestimate the important role language plays. Communities share knowledge through written and verbal language. Don't assume that all community members have the same fluency level.

Understand the difference between teams, communities of practice and CKNs. At AFSIT there is a GOLD team, within Skandia AFS there is a GOLD community of practice. The GOLD team has a specific objective - to develop and deploy the GOLD solution. The Gold community is designed to share knowledge about GOLD and its uses. The community of practice is one special type of collaborative knowledge network. The GOLD team is comprised of full-time members focused on its objective. The GOLD community is comprised of the team and champions, and the champions may work on non-GOLD projects when they return home. The GOLD team has a project manager and the community doesn't. The GOLD team may disband when GOLD has been completely adopted, or when its knowledge has been diffused throughout the organisation. Finally, the GOLD community management is focused on building relationships and not delivering applications.

Successful CKNs need some organisational catalyst; that is they need some individual or group to drive the community's creation. In AFSIT's case, that yeast is the GOLD team. Their success depends on having a functional community.

CKNs are not designed for the rapid deployment of learning. The GOLD team brings participants to Shelton for extended periods. Only when there is relatively long contact between community members can the social bonds begin to form that lead to long-term continual knowledge exchanges.
Ongoing communication must be face-to-face as well as virtual. A web-site alone is not a community. It is only a tool that won't be used if the community relationships aren't in place. The GOLD team actively visits each LBU to maintain the relationships it's carefully developed. These visits supplement the material and communication available through the GOLD web site.
Finally, in today's networked economy, where companies are becoming more and more decentralised, CKNs appear to be an effective way of sharing knowledge across an organisation. In the case of Skandia AFSIT and its GOLD team, this certainly seems to be the case.

6. CONCLUSIONS

This section has briefly outlined collaborative knowledge networks and communities, their features, challenges and some recommendations. The focus has been on how people act in such unusual organizational environments, and the potential impact their behavior has on CKN effectiveness. It is intended to give some guidance to people who may be starting their own networks. The number of unresolved challenges outlined above shows that there is still a significant need for research in the field of CKNs and Virtual Organizations and their members' behaviors.

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PERFORMANCE MEASUREMENT AND ADDED VALUE OF NETWORKS

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Within this chapter, the authors suggest that networks need tailored performance measurement tools, if they want to succeed in showing their superiority over traditional ways of delivering solutions. However, in order to assess their added value, networks first must be aware of their purpose(s). The paper starts with a definition of performance management and measurement followed by a classification scheme which supports the identification of the most appropriate method for measuring performance or value added of networks: Goal-driven networks are likely to use more traditional performance measurement whilst capability enhancement-driven networks need distinctly new approaches, for instance methods for mapping the flows of Intellectual Capital which are presented in greater detail in this chapter as well. Based on these insights, research challenges for the measurement of the network's added value are proposed.

1. USING PERFORMANCE MANAGEMENT WITHIN NETWORKS

Recent literature defines *performance management* as (Roth, 2002);

- methods,
- processes,
- structures and
- behavioral patterns

an organization uses **to improve performance.**

Performance management may be used during strategic and operative (tactical) planning, execution (or implementation) and communication stages activity. As part of the communication activity, *performance measurement* is the process that gathers and records the effectiveness and efficiency of the execution (action) and planning stages. Thus performance measurement can be considered a subset of performance management.

Performance Management (PM) is proposed to be a powerful enabling tool for developing a company's business. Certainly performance measurement can be

applied to various application fields, such as product development, manufacturing, sales etc. However, traditional performance measurement operates in most cases at a corporate level supporting the improvement of a company's performance. By pinpointing to the biggest improvement potentials PM contributes to a sustainable business development.

Established approaches (Pritchard, 1990; Kaplan and Norton, 1996; Edvinsson, 1997; Sveiby, 1997) have in common that their application has mainly been investigated within clearly defined organizational structures. Recently new concepts like collaborative knowledge networks have moved onto the research agenda, therefore the emerging question is how those new paradigms, concepts and theories interact with the subject of performance measurement.

Performance Measurement always has to rely on the premises the measurement system is built upon. The emergence of collaborative knowledge networks increasingly challenges the premises that have been used in the past and questions their applicability in the new context. For instance, collaborative networks are dependent on the individual knowledge of its participants. In contrast to former times, the exchange activities in networks deal predominantly with the exchange of intangibles, i.e. information, knowledge, competencies that are incorporated in certain goods and services. However, information and knowledge are volatile and may lose their value from one day to another, to a certain extent they are easy to copy and easy to distribute and in combination with Information Technology usage, a high market transparency can be achieved. Now that the rules of the game have changed, how is this reflected in the performance measurement, whose objective so far is to ensure the competitiveness of *single* organizations?

For maturing networks that desire to implement professional-type systems, a measurement system may be a tool that they consider. The standard literature provides many useful insights; however extra care is needed within the special environment of networks to transparency (e.g. so that every member understands the same measure in the same way), of participation (e.g. every member being involved in the creation of the measurement system and its measures), and of alignment (e.g. every members' goals are coherent with the measurement) which are major requirements for measuring performance. The question is therefore how these requirements can be met within those new business environments. The following section proposes therefore a classification scheme which supports the identification of the most appropriate method for measuring performance or value added of networks. One specific approach for measuring the value added of networks is presented in greater detail as well.

2. ASSESSING THE ADDED VALUE OF NETWORKS

Collaborative networks often struggle to show their superiority over traditional methods of meeting the same objectives. This section proposes methods to assess such added value.

Assessment of network added value clearly needs to be based upon purpose. Only if the purpose of the members is clearly identified can sound assessment of added value be feasible. The purposes for joining networks are manifold and often depend on the general nature of the network (see Figure **1**):

On the one hand there are networks which are goal-driven, where the objective is to deliver something within stated time, cost and quality goals. These networks exhibit characteristics similar to project teams, having a bounded task. In this case often savings in time and cost compared to the "non-network" alternative are the decisive factors for using a network. EC projects are examples of networks which are driven mainly by a concrete mission and goals. On the other hand there are networks which are more driven by purely personal goals like capability improvement or knowledge sharing purposes. The LINUX community, the Institution of Electrical and Electronic Engineering (IEEE) are examples for that type of network.

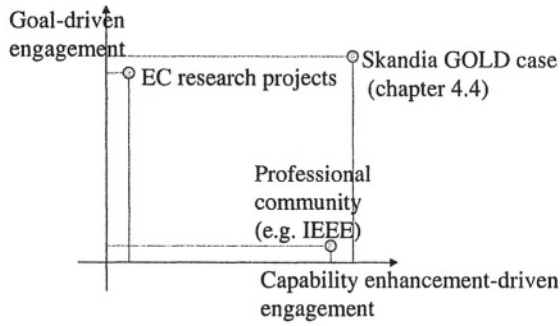

Figure 1- Purposes for joining networks

The assessment of added value for the goal-driven networks relies on the standard technique of measuring the cost and time it takes to achieve a quality goal. The network is a better method only if the cost or time is reduced. Note that some networks coalesce in order to improve the quality of a solution; in these cases it is also feasible to compare the network and non-network values by imagining the non-network solution that would be needed to deliver the same qualities (for example, how much does it cost to have custom meals delivered to your home every day can be compared to a chef service to achieve the same quality level. It should not be compared to the existing service which offers inferior quality).

The other main network type typically has objectives to improve the capability of its members (such as professional communities). Such networks do NOT have a time-bounded goal and cannot therefore assess their added value by measuring the resources taken to achieve the goal. The added value of these networks is centered on their ability to improve their members' capability (for example, by increasing skills, knowing new people, finding new tools, learning from others experiences). Measurement of such capability- and learning-centered network activities can hardly be found in the literature so far. Educational performance measurement research does not assist in the assessment of network specific contributions to improve members' capability (this means that a network should not be seen as adding value if a member gets a degree, as this did not come from the networks activities but from the member acting separately to the network).

The capability enhancement-driven type of network needs to assess the quantity and quality of sharing and creation of Intellectual Capital (IC) within the network. Dvir (2003) proposes within his IC mapping methodology that the intensity of

knowledge exchange, its creation within each leave of the IC tree (see Fig 2. below) is a valuable means for assessing the value added of a network. The IC map showed below should be applied for various members within a network to ensure a valid basis.

A blank hard copy template is presented to the interviewee. He scores the roots of each main IC category (e.g. Human Capital, Structural capital) in a bottom-up sequence, i.e. firstly the lower level roots. The scoring is done through a conversation between the interviewee and the interviewer, which refers to the meaning of each leave, the reasons for scoring, and other comments, which are documented by the interviewer. The IC framework offers questions to structure such conversations. Then the flows between members are captured; this means direct questioning about what capabilities are being enhanced by learning in the network.

The assessment for each individual bottom-level root is based on the subjective perception of the interviewee, using the legend. The basic codes are:

Very Strong	very strong – black
Good	good – dark grey
Fair	fair –grey
Weak	weak – white
Not applicable	not applicable – dotted
Don't know	the assessor didn't have enough information to score – dotted

After the interview, the researcher codes the manually entered colored map into an MS-Organization chart.

The added value of the network is assessed as the total of all the IC flows between its members. Such a tool offers one method to assess the added value of those networks which meet their objective through its members improving their own Intellectual Capital. Of course many real networks exhibit both characteristics – they are both goal-driven and capability enhancement-driven. The GOLD community case in 4.4 illustrates this clearly; even structuring itself to reflect both purposes. In this case added-value assessment of the GOLD community would use both approaches; measuring the reduced cost or time when a network approach is used to implement the GOLD system across the global organization and assessing the quantity of flows of Intellectual Capital between its members.

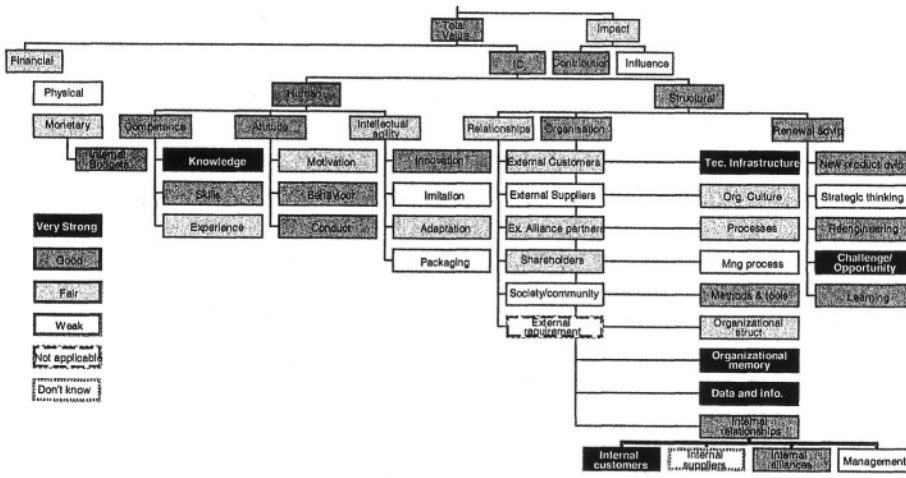

Figure 2: Overview on the IC map (Dvir, 2003)

3. MEASUREMENT OF VALUE ADDED WITHIN NETWORKS – THE RESEARCH CHALLENGES

The whole state of the art presented in the earlier sections refers to more traditional organizational forms with traditional processes, strategy planning processes etc. However, in a network context, where are the boundaries of measurement? How detailed can one measure without affecting the networks creativity? Who will perform the performance assessment and derive suitable measures that will be followed by the network members? The complexity of relations in a network and the sheer existence of a variety of contributors in a network makes measurement more difficult as there are more "objects" that have to be measured.

- **The first challenge is therefore to analyze in detail the role of and required design principles for performance measurement in the context of collaborative knowledge networks.**

Kemp and von Wendel de Joode (2002) have written an interesting article where they elaborate on the strategy finding task in the context of the LINUX community. Generally people distinguish between emergent, resource-based or top-down, market-based strategy definition. Due to the high volatility of the system the authors propose that communities should rely on emergent, dynamic and implicit strategy definition. However this implicit strategy finding forms a great challenge for performance measurement.

- **Challenge two is to discover which levels of stability encourage long-term improvement through performance measurement while maintaining the network adaptability.**

The purposes for performance measurement above have shown that performance measurement is more than just doing measurement to see where the company is. Performance measurement is a key communication instrument which emphasizes the transparency of the measures and the participation of members in creating the measurement system.

- **Challenge three is to research how performance measurement systems can be defined in transparent and participative way.**

Each partner in a network or alliance may have its own business processes and reporting structures. Each partner may have different aims and objective as well.

- **The challenge is therefore how to design and use a network performance measurement system which suits the different requirements and aims of different, individual stakeholders – Challenge four** (McKinsey, 2002).

Assessing added value is a challenge as well, because of interdependencies between networks and their members' parent organization and because of different 'value' objectives that different members bring. As multiple partners contribute to a network's success, where do you actually measure?

- **What are the appropriate ways to assess added value for different network types, and how to separate performance coming from the network, the member and the members' parent organization is challenge five** (McKinsey, 2002).

4. CONCLUSION

The particular characteristics of collaborative knowledge networks vary amongst specific networks. For some networks that more closely resemble projects the traditional knowledge and practice of performance measurement may be reasonable. But most networks do not behave this way and performance measurement systems need to take special care over issues of transparency, alignment to parent goals and participation. A number of research challenges relating to this have been elaborated.

The added value that is created by these new organizational forms also escapes capture. The authors propose that a combination of classic cost-benefit analysis for goal-driven networks and Intellectual Capital Mapping for capability enhancement-driven networks as an appropriate solution.

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ETHICAL AND MORAL ISSUES FACING THE VIRTUAL ORGANIZATION

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Much has been written about business ethics and morality and how business and society should respond, if at all to these issues. From a research perspective, given the radical transformation of business and companies in the developed world during the last fifty years and this transformation's global spread two questions emerge. Do current approaches to understanding business ethics and morality help identify the collaborative, networked organization's ethics and morality? And, will collaborative, networked organizations emphasize one set of ethical and moral responses over others? This essay seeks to develop answers to these two questions. It argues that the ethics and morality of the collaborative network are emergent properties; and collaborative networks will increasingly reflect a stakeholder approach.

1. OVERVIEW

Seattle. Davos. Gothenberg. Beyond their usual connotation as interesting cities or resorts, they have recently acquired a new meaning.. .as focal points for a growing unrest with global capitalism among environmentalists, labor activists, human rights and economic development groups. At a public level these groups articulate to varying degrees their disagreement with, and perhaps fear of, what Fukuyama (1992) called the End of History.

Fukuyama argued that History, at least in Heglian terms, had come to an end with the triumph of liberal democracy and "free-market" capitalism (Fukuyama 1992). He writes:

"All countries undergoing economic modernization must increasingly resemble one another: they must unify nationally on the basis of a centralized state, urbanise, replace traditional forms of social organization like tribe, sect, and family with economically rational ones based on function and efficiency, and provide for the universal education of their citizens. Such societies have increasingly linked with one another through global markets and the spread of a universal consumer culture."[l]

The replacement of traditional forms of societal organization, the emergence of a global consumer-driven culture, the need to unify around a centralized national state is disruptive. The speed at which this disruption is occurring has increased dramatically in the last fifty years. So it should not be surprising that groups would organize to oppose these trends. This opposition leads to the type of conflict

exhibited at meetings of the World Economic Forum, the World Bank or the International Monetary Fund. This conflict can also lead to economic development.

This idea that economic development involves more than lowering trade barriers or creating new stock exchanges is reflected in the new economic thinking embodied in the works of Nobel laureates Ronald Coase and Douglass North among others. What they refer to as economic development is seen as more than just the refinement of the rational marketplace. Rather economic development is driven by the frisson between differing perceptions of the world and the institutions and organizations that embody these perceptions. As one set of perceptions (and by extension institutions and organizations) gains prominence over another, conflicts develop, are resolved and economies reach a new stage of development.

It is important to understand the difference between institutions and organizations in order to fully appreciate the importance ethics and morality plays in economic development. North (1993) states that institutions are "the rules of the game of a society or more formally are the human-devised constraints that structure human interaction. They are composed of formal rules (statute law, common law, regulations), informal constraints (conventions, norms of behavior and self-imposed codes of conduct) and the enforcement characteristics of both. Organizations are the players, groups of individuals bound by a common purpose to achieve objectives. They include political bodies (political parties, the senate, a city council, a regulatory agency); economic bodies (firms, trade unions, family farms, cooperatives); social bodies (churches, clubs, athletic associations); and educational bodies (schools, colleges, vocational training centers)"[2].

Ethics and morality are key components of the formal and informal "rules of the game" within which organizations operate. Economic development challenges the ethics and morality of those societies or groups undergoing the transformation. It should not be surprising then, that an ethical or moral conflict often lies beneath the veneer of the specific policy arguments raised during these protests. At this more fundamental level, these challenge all institutions and organizations to understand and respond to the ethical and moral issues confronting society.

If economic development can be seen as an ongoing struggle and resolution between the competing world views of groups then the interesting question is: why are these groups so recently focusing their protests against business and economic institutions rather than other institutions and organizations such as government or religion? The answer lies in two parts.

First business, next to family and arguably before religion and government, is the most important way individuals organize themselves to realize a specific purpose. Business supplies the economic engine that drives all societies towards success or failure and as such directly impacts the quality and standard of living of individuals. And economic institutions often dictate and influence the monetary policies that directly affect the lives of communities and individuals.

Secondly, and perhaps more importantly, business driven by both collapsing national and technological barriers has undergone a profound transformation during the last fifty years. Business has evolved, especially in the developed world, from locally-oriented, paternalistic, organizations industrial organizations towards global, networked firms operating in a collaborative manner and often exhibiting and expecting little loyalty from customers, employees or partners. The rapidity of this

change has made business the global face of economic development. As such business has become a singular target for groups seeking to raise ethical and moral challenges.

Much has been written about business ethics and morality and how business and society should respond, if at all to these issues. From a research perspective, given the radical transformation of business and companies in the developed world during the last fifty years and this transformation's global spread two questions emerge. Do current approaches to understanding business ethics and morality help identify the collaborative, networked organization's ethics and morality? And, will collaborative, networked organizations emphasize one set of ethical and moral issues responses over others? This essay seeks to develop answers to these two questions. This essay argues that the ethics and morality of the collaborative, networked organization are emergent properties; and collaborative networks will increasingly embrace a stakeholder approach.

Answering the first question requires two steps. First the relationship between the "idea of the firm" and business ethics and morality needs to be understood. Secondly the collaborative, networked organization's impact on the "idea of the firm" needs to be examined to gain an understanding of its ethical and moral issues. Only then can a conclusion be drawn and the question answered.

The second question requires identifying how organizations typically respond to ethical and moral issues. These responses can be analyzed to determine whether one response is better suited to a collaborative, networked organization than another. Based on this analysis a conclusion about how collaborative networked organizations will respond can be developed.

Before any of these steps can begin, however, it is important to define what this essay means by the term business ethics and morality.

2. WHAT ARE BUSINESS ETHICS AND MORALITY?

In order to understand the ethical and moral issues facing collaborative, networked organizations, it is necessary to first define "business ethics and morality". This is a difficult task since the general public tends to use the terms ethics and morality interchangeably.

This difficulty is further enhanced when discussing ethics and morality as they relate to business because of the addition of the term "corporate social responsibility" and its use as a proxy for business ethics and morality. A clear distinction between these terms allows a degree of order to be brought to the subject and provides a solid foundation from which a deeper understanding can be built.

Webster's (1988) defines business as "a usually mercantile or commercial activity engaged in as a means to a livelihood...a commercial or sometimes an industrial enterprise". It defines ethics as: "a set of moral principals or values" and further as: "the principals of conduct governing individuals or a group". It further defines moral as "relating to principals of right and wrong in behavior" and again as "expressing or teaching a conception of right behavior" and morality as "a doctrine or system of moral conduct [3].

Thomas Donaldson, Professor of Legal Studies at the University of Pennsylvania

and noted business ethicist defines business as follows (Donaldson 1999): 'For clarity, let us stipulate, then, that 'business' refers to productive organizations: one where people cooperate to produce at least one specific product or service. Productive organizations would include corporations (of the productive sort), manufacturing partnerships, and service organizations." [4].

Lawrence Hinman, director of the Values Institute at the University of San Diego, defines ethics as (Hinman 2003): "The explicit, philosophical reflection on moral beliefs and practices. The difference between ethics and morality is similar to the difference between musicology and music. Ethics is a conscious stepping back and reflecting on morality, just as musicology is a conscious reflection on music." He defines morality as the "first-order beliefs and practices about good and evil by means of which we guide our behavior. Contrast with ethics, which is the second-order, reflective consideration of our moral beliefs and practices." [5].

From these definitions a useful distinction begins to emerge. Ethics is the enactment, by individuals or groups, of their moral beliefs. Morals, and morality, are the foundation beliefs held by those individuals or groups. At a simple level then, business ethics and morality can be defined as the underlying principles of right and wrong behavior by productive organizations engaged in commerce and the formal and informal systems put in place to encourage or inhibit that behavior.

But this definition tells little about the source of these underlying principles or how they are constructed. Fortunately the field of ethical philosophy offers some help in further developing this definition. Ethical philosophy studies the relationships between morality and ethics and the various approaches to building ethical systems.

While an in-depth discussion of ethical philosophy is far beyond the scope of this essay, a brief overview does help develop the framework necessary to understand business ethics and morality. The biggest contribution ethical philosophy makes is in providing methodologies to identify business's moral foundation.

Ethical philosophy has identified two generally accepted methods used in grouping ethical codes. These are the normative or metaethics methods.

Normative ethics creates or evaluates moral standards in an attempt to identify how people should behave or whether their moral standards are reasonable. Metaethics concerns itself with the purpose or origin of the moral standards. The following example is a simple way to understand the differences. Suppose an individual or group have a moral belief that life is sacred and must be respected. From this belief a set of ethics emerges. This ethical set, or code, might contain a principal against taking life under any circumstance.

In this example normative ethics might state the principal as "Killing is wrong and is prohibited". Metaethics could state its principal as "Taking a life is wrong because it destroys that which is sacred and is disrespectful to both the killer and victim, and so is prohibited." Normative ethics makes a judgment about the act of killing, that it is "wrong". Metaethics moves beyond the Normative to explain that killing is wrong because it destroys the sacred and is disrespectful.

These categories allow further progress towards understanding what is meant by "business ethics and morality". Debates and discussions about issues such as pollution, employment practices, working conditions, engagement with local political authorities usually center around on developing codes or standards of how

business should behave in these areas. As Donaldson (2000) explains these codes and standards do not explain the purpose or reasoning behind them, rather they establish parameters for action. For this reason, because the public debates often focus on the how and not the why the normative approach provides the clearest way to understand business ethics and morality.

Ethical philosophy has identified three main approaches to developing and understanding normative ethical codes or standards. These are the Virtue, Teleological or Deontological approaches.

The Virtue approach derives its principals from what *enhances* virtues and *inhibits* vices among the individuals or groups covered by the ethical system. In order to develop a normative set of ethics using this approach it is necessary to identify good virtues and bad vices. Ethical principals encourage the development of positive virtues and inhibit the spread of bad vices.

While this approach has an ancient pedigree, with its roots in Plato and Aristotle as well as medieval Christian theology, it requires the identification of cardinal virtues and vices by some individual or group. Over time, and especially since the enlightenment, this has been seen as a rather arbitrary way to develop ethical and moral codes. Over the last 300 years ethical philosophy has strived to develop a more rational way to identify ethic's moral foundation. The results of this effort are broadly known as the Teleological and Deontological approaches. Both the teleological and deontological methods have their adherents and, not surprisingly, are the source of continuing debate and refinement.

The Teleological approach, from the Greek *teleos* for end, derives its principals from the end result produced by the ethical system for the individuals or groups. This approach became popular in the 18th and early 19th century by philosophers, especially Jeremy Bentham and James and John Stuart Mills, who wanted a way to morally assess ethics by analyzing the experience resulting from an action. These philosophers were dissatisfied with moral assessments based upon the rights or obligations incumbent upon groups or individuals since they felt there was no guarantee that honoring an obligation or right would always result in a social good. From their perspective it was the end result, the outcome produced from the ethical system that was important.

In order to develop a normative set of ethics using this approach it is necessary to weigh the good and bad consequences of the individual or groups actions and make a cost benefit analysis to determine what is or is not ethical. Where good consequences outweigh the bad, then that becomes an ethical principal.

With this approach, what is considered good or bad depends upon the point-of-view used in making the decision. "Goodness" or "badness" can be determined from the point-of-view of the person or group. In this case what benefits them is good and what harms them is bad. A second way to determine good or bad is from the point-of-view of everyone except the person or group. In this case what benefits everyone else is good. The final way to determine what is good or bad is by taking the utilitarian point-of-view, which Bentham and the Mills argued was the best, that whatever does the greatest good for everyone is the morally correct principle.

The Deontological approach, from the Greek word *deon* for duty, derives its principals from the duties, obligations or rights of the individuals or groups covered by the ethical system. Based on ideas developed in the 17th century by Hugo Grotius

and Samuel Pufendorf and enhanced and refined by Thomas Hobbes, John Locke, Jean Jacques Rousseau and Immanuel Kant, deontological approaches understand morality as a set of obligations or duties incumbent upon, or rights possessed by, individuals or groups regardless of the outcome.

In order to develop a normative set of ethics using this approach it is necessary to identify the fundamental obligations and duties incumbent on the individual or group. Whatever the obligation or duty is, that is what is ethical. The ethical system is then constructed to reinforce those obligations. These fundamental obligations may be found in expressed duties to religions, families or self; they could be found within the rights possessed by the individuals or group; they could be found in Kant's categorical imperative.

One important deontological approach that impacts business ethics and morality is Contractualism originating in Hobbe's concept of the Social Contract and most recently developed by John Rawls. Social Contract theory identifies ethics and morality not as some antecedent truth that is revealed by religion, inherent in a rigid set of virtues or vices or the end result of an action.

Social Contract theory argues instead that ethics and morality are the result of the agreement between a society and its participants. Before the social contract actions are neither moral nor immoral; it is only after the contract has been "negotiated" that ethics and morality can be identified. Another way of understanding this is that ethics and morality are the boundary established by the social contract.

For a social contract to be valid it must contain two distinct components. The first is that it must provide clear benefits to the parties involved in the contract and the second is that it must provide obligations that must be fulfilled by those participants. The negotiation of both the benefits and obligations is the process that eventually produces the social contract. Social contract theory further recognizes that even after the contract has been established it is not frozen, but instead undergoes continual renegotiation.

Interest in social contract theory declined during the 19th century as the ideological arguments made by Bentham and the Mills' gained acceptance. However during the 20th century the work of John Rawls, most noticeable in his 1971 book "A Theory of Justice" began to reverse the trend. Arguing that the utilitarian approach provided no inherent restriction on the subordination of some people's rights or interests to others, so long as the net outcome was good, Rawls sought to demonstrate that society rests on mutually beneficial agreements that establish fundamental rights and obligations.

When these approaches to developing normative ethical systems are applied to business ethics and morality this debate seems, at first glance, to be replaying itself. On one side there appears to be those who argue from a teleological perspective that business ethics is about producing the greatest good for the greatest number of people. While those opposing argue from a deontological point-of-view that business ethics and morality is based on narrowly defined duties and obligations.

However, as will be developed later, when the arguments are examined more closely it becomes apparent that behind differences lies a fundamental disagreement about business's social obligations. This emphasis on social obligations clearly points to a deontological approach to identifying business ethics and morality and

specifically to the use of social contract theory to identify business ethics and morality.

And it is from the idea of a social contract between business and society that the meaning of "corporate social responsibility" now becomes clear. Corporate Social Responsibility can be thought of as business honoring its obligations under its social contract. Companies that meet or exceed their moral and ethical obligations could be said to be acting in a social responsible manner; while those that fail to meet those obligations act in an un-responsible manner.

Ethical philosophy has helped, even within this brief overview, to provide a clear and meaningful definition of business ethics and morality as well as corporate social responsibility. Business ethics and morality can be defined as the underlying principles of right and wrong behavior by productive organizations engaged in commerce and the formal and informal systems put in place to encourage or inhibit that behavior; these systems can be expressed as taking the form of a social contract and business and society have the responsibility to honor their mutual obligations under the contract.

With a clear understanding of what business ethics and morality are, and how they are identified it now becomes possible to address the first specific question. Do current approaches to understanding business ethics and morality help identify the collaborative networked organization's ethics and morality?

3. CURRENT APPROACHES TO UNDERSTANDING BUSINESS ETHICS AND MORALITY AND THE COLLABORATIVE, NETWORKED ORGANIZATION

Business ethics and morality are a growing area of interest both within and without academia. Ethical philosophy has provided a methodology to frame the area and a language to discuss and debate with. However this method and language was developed in an earlier economic era. This leads to the research question: Do current approaches to understanding business ethics and morality help identify the collaborative networked organization's ethics and morality?

Using the definition and understanding gained in the previous section this essay argues that the current approaches do not help identify the ethics and morality of collaborative networked organizations. Rather a new approach must be used to understand these ethics and morality. It goes further to argue that a new approach can be found not within ethical philosophy, but resides instead in the science of complex adaptive systems, specifically as an emergent property of that organization.

Three areas must be examined before a conclusion can be drawn that supports this proposition. First the current approaches to understanding business ethics must be reviewed. Secondly, the collaborative networked organization must be defined and its impact on these current approaches analyzed. Thirdly, alternatives to these approaches can be examined. Finally a conclusion can be reached.

3.1 The idea of the firm and its Impact on business ethics.

Understanding the current approaches to business ethics and morality requires

examining the role the idea of the firm plays in establishing these ethics and morality. This is necessary because business, like government, is not a natural entity. This is especially true when business takes the form of companies or corporations. Donaldson (1999) wrote: "...corporations, unlike humans are artifacts, which is to say we create them. We choose to create corporations and we might choose either to not create them or to create different entities. Corporations thus are like political states in their need for justification." [6].

Social contract theory does more than provide an ethical methodology to understand business's obligations. Beyond explaining the boundaries applying to both business and society, it helps provide an understanding of why business is formed, just as political social contracts help explain why governments are formed. It does this by reflecting the agreement between society and business and the purpose each provides for the other.

It is this justification argument, why business organizations are formed and their role in society, that lies at the heart of the debate about business ethics and morality. The debate reflects competing answers to the justification question. Some would argue that business and corporations have the "right" to exist in the same sense as a person. Others argue that the production of goods and services justifies the creation of business and corporations. Still others argue that these reasons fail to justify the creation of business or corporations or explain their moral obligations.

Neil Shankman writes in the Journal of Business Ethics that this debate can "...best be characterized as a reflection of an ongoing struggle between economic views of the firm which are decidedly silent on the moral implications of the modern corporation, and ethicists who place the need for understanding ethical implications in a central role in the field of business ethics." [7].

Because the answer to the justification question determines the boundaries business and society place on each other through the social contract it is crucial to gain an understanding of the main ideas of the firm that influence this debate and the tension between them. This understanding can then be applied to the collaborative, networked organization with an eye towards determining which idea best matches the new organizational form.

Historically two broad approaches to understanding the justification for creating corporations have been argued in the modern economy. These are known as the agency and stakeholder theories of the firm.

Agency theory finds its roots in an idea of the firm started by Adam Smith and popularized by Milton Friedman in his seminal 1970 article "The Social Responsibility of Business". This argument, also often referred to as "Anglo-American capitalism" to reflect the geographic region where it predominates, holds that business and corporations are formed to more effectively produce goods and services that society needs or wants. The moral obligation of business and corporations is to produce these goods and services within the ethical and legal framework of their society.

In return for these goods and services society recognizes the moral right for the business or corporation to exist and has an ethical obligation to protect the business or corporation and its property to the same degree as it protects the person and property of individuals. In addition the managers of the firm have a moral obligation

to do their best to generate a profit for the owners and lenders by prudently spending the capital they provide.

This narrowly constructed view of the idea of the firm and the obligations stemming from it troubles many. While granting that business or corporations are formed to create goods and services, this view identifies a much broader range of obligations incumbent on the business and its managers than the agent theory allows.

This broadness derives from the fact that the business or corporations has a much less clear "right" to exist, but rather is often said to be granted a "license to operate". Failing to meet these broader obligations can lead to the negation and removal of the license This argument derives from the idea that a business interacts with many different groups other than just capital providers, managers and owners; and that these groups contribute to the creation of the business albeit in a different form.

From this unease arose the second major idea of the firm, often termed "stakeholder capitalism", also known as "continental capitalism" reflecting it predominance on the European mainland. R.E. Freeman developed this theory in his 1984 book "Strategic Management: a stakeholder approach." In it he defined the concept of the stakeholder, identified the relationships and responsibilities between the stakeholders and the corporation.

Agency theory takes as its basis the idea that one group or individual performs certain duties for another group or individual in exchange for economic reward. The Agent is the group or individual performing the duties and the Principal is the group or individual who is paying the economic reward. Agency theory then views the company as a collection of agent-principal relationships, usually with the relationship between the shareholder (as principal) and the manager (as agent). Those like Friedman who support this view also argue that the primary reason the average shareholder invests their capital and hires managers is to increase their wealth. Put simply, agency theory argues that shareholders hire managers and charge them with the responsibility of increasing the return on the investment.

To the extent that managers spend resources on things other than producing goods and services or generating profit they are acting unethically by not meeting their moral obligation to the shareholder or capital providers. Likewise to the extent that society imposes requirements on business to do other than produce goods or services or for managers to do other than generate profits it inhibits the fulfillment of the managers ethical obligation. Finally to the extent that resources are spent by the manager or extracted by society on non-productive activities reduces the firm's obligation to produce goods and services.

The social contract between business and society from an agent theory perspective is therefore an ongoing negotiation to establish the minimum ethical and legal requirements necessary for both sides to meet their obligations and enjoy their benefits.

Stakeholder theory does not *exclude* the agent-principal relationship between manager and shareholder. Rather it increases the number of relationships the firm must consider when identifying its social obligations. These relationships can be with the business's workers, customers and partners. It could also be the community where the business is located. In fact identifying and defining who has a legitimate claim to the title of stakeholder occupies a significant part of the approach. This identification can range from only those who have narrow economic relationships

with the firm (e.g. shareholder, employees, customers and partners) to broad views that include any person or group affected by the firm (e.g. local communities, academics).

The key difference between agency and stakeholder views of the firm is that stakeholder theory does not assign *primacy* to the shareholder-manager relationship.

The social contract between business and society from a stakeholder perspective is therefore an ongoing negotiation to identify these stakeholders and the specific obligations incumbent upon business to these stakeholders.

Both ideas of the firm impact the how business ethics and morality is perceived and approached. It is the effort to identify and prioritize stakeholders, and the ethical and moral responsibilities business has to them, that occupy much of the broader protest and debates.

With this understanding of how the idea of the firm creates business's social contract it is now possible to consider the impact collaborative, networked organizations have. Specifically do collaborative, networked organizations bring into question the idea of the firm?

3.2 What is the collaborative networked organization and how does it impact current approaches to business ethics and morality?

A collaborative networked organization, like business ethics and morality is not a clearly defined term. Henry Mintzenberg in his book *The Structuring of Organizations* identified five organizational models and the operating environments they tended to prefer (Mintzberg 1979). These models are [8]:

The Entrepreneurial structure...Organizations that are young, small and dominated by a single entrepreneur or CEO. They tend to exist in a fast changing environment.

Machine bureaucracy...Large companies organized into functional units with strong centralized decision making and producing a standardized product. These tend to exist in slow changing stable environments.

Professional bureaucracy...Knowledge based company dominated by department heads with weak central decision making. These usually operate in slowly changing environments.

Divisional bureaucracy...A combination of many machine bureaucracies, each producing different products or services with a common central head office. These tend to exist in slowly changing environments, however the different divisions may operate in different environments.

Adhocracy...A "task force" created to respond to a specific challenge or opportunity. These form, dissolve and reform in new combinations based on the challenge or opportunity. These firms respond and exist in rapidly changing environments, are more innovative than machine bureaucracies, more flexible than professional bureaucracies and are more sustained and effective than entrepreneurial firms. Central management is weak.

Gareth Morgan, Professor at Toronto's Schulich School of Business eloquently describes the collaborative, networked organization and its environment in his book *Images of Organization*: "It is a form highly suited for the performance of complex and uncertain tasks in turbulent environments. It usually involves project teams that

come together to perform a task and disappear when the task is over, with members regrouping in other teams devoted to other projects. Sometimes, this kind of enterprise is called a "virtual" or "network" organization, especially when teams and team members are spread geographically, using electronic technology and occasional face-to-face meetings to integrate their activities. Adhocracies, "virtual teams", and "virtual organizations" now abound in innovative firms in the electronic and other high-tech and rapidly changing industries." [9].

What's important to realize is that within a collaborative networked organization the relationships between participants is virtual, lasting only until the association no longer produces value for each participant. This is the key identifier of the collaborative, networked organization, its focus on value-added relationships. If a participant feels they are not getting value for their association, they can leave the collaborative, networked organization or find some new partner who does add value. It's this ability to quickly form or sever relationships that gives the collaborative, networked organization its competitive advantage in a turbulent environment.

What does a collaborative, networked organization look like? Figure 1 is an example of a simple collaborative, networked organization derived from Mintzberg and Morgan's definitions.

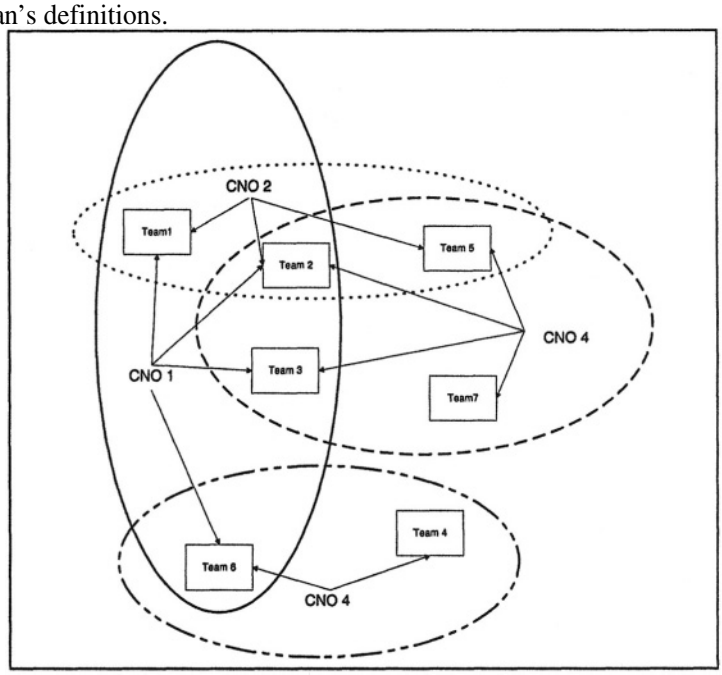

Figure 1- Example of a collaborative networked organization

These teams may be part of some larger company or they may be individual companies or they may be some combination of the two.

Earlier, Social Contract Theory was identified as a solid approach to understanding business ethics and morality; will it help identify the ethics and morality for a collaborative networked organization? From a social contract perspective it is evident that each participant, or node, in a collaborative, networked

environment has its own social contract. As a result it can be stated that each node therefore has ethical and moral obligations that derive from its unique social contract. The question becomes whether or not there is a *collective* social contract applicable to the entire network? This is more than just a hypothetical question; rather it has real-world implications.

One classic example of the real-world implications of whether a collective ethical and moral obligation exists is found in the Nike controversy. Nike operates as a collaborative, networked organization in order to produce its products. Within this collaborative network Nike handles product design, marketing and sales from its Oregon, USA headquarters while manufacturing is done by independent firms usually located within the developing world.

Nike's problem arose when the labor practices and working conditions of its network partners were challenged. Nike was attacked because a part of its network acted in what some Nike stakeholders perceived to be an unethical or immoral manner. Nike spent enormous resources in addressing these attacks and altered its network to alleviate the pressure it felt. While Nike had a clear *strategic* business reason to respond to these attacks did it have an ethical or moral obligation to answer them? The answer to this is question is crucial because if Nike had no ethical or moral obligation then it has the option to address or not address the behavior of its partners.

Using a Social Contract theory to answer to this question requires determining whether or not a social contract exists between the collaborative, networked organization and society. One could answer yes because of the idea that one reason organizations form is to reduce transaction costs. This idea, developed and advanced by Ronald Coase in his 1937 book The Theory of the Firm, holds that organizations seek to lower the costs of conducting business both within the organization and with its customers. Those organizational forms that provide lower transaction costs should be preferred over those forms that don't.

In order for a collaborative, networked organization to be a more effective organizational choice than other organizational forms, the transaction costs between the nodes must be lower than in the alternatives. It is this theory that drives the recent management trend towards focusing an organization around core-competencies and outsourcing non-core activities. The perception that collaborative networked organizations enjoy lower transactions, than alternative organizational forms, accounts for part of their growing dominance.

Technology is usually cited as a key driver in lowering these costs, but equally important is the presence of a social environment where the participating nodes can be assured of a high level of trust among the nodes; and the nodes need the ability to seek redress when this trust has been violated. In addition Western legal theory lends support to the idea of collective responsibility and guilt when it prosecutes collaborative, networked organizations that engage in criminal activities (e.g. organized crime or terrorist organizations).

Therefore a social contract could be constructed that says: in exchange for the collaborative, networked organization's effectively producing and delivering goods and services to society and not engaging in criminal activities, society will provide a legal framework that raises the level of trust among the nodes and provide an enforcement mechanism that discourages violations of that trust.

While a potential social contract can be articulated it must be tested to determine whether it is valid. Just because society provides an environment that enables collaborative, networked organizations to form and does prosecute those that engage in criminal activity, is that enough to prove accept the idea of a social contract for collaborative networked organizations?

Several points weaken the argument for the existence of a social contract for collaborative networks. First, society does not provide any unique or specific rights or benefits to the collaborative networked organization as a *collective.* At the same time it imposes no collective obligation upon the collaborative networked organization. Instead individual nodes posses these rights, benefits and obligations.

Secondly the collaborative network does not exercise collective action. For instance, the *collective* organization does not own property. It does not have shareholders. It does not hire, or fire, workers. It does not have customers or creditors. The collaborative network doesn't pay taxes or have other obligations to society. These are actions undertaken by the individual nodes within the network.

Thirdly, the collective organization does not posses the legal recognition as an unique entity, this recognition is instead granted by society to the individual nodes. Additionally the nodes themselves are not required to be permanent members. In fact one of the key competitive advantages, as Morgan pointed out, is the fact that collaborative, networked organizations can quickly reshape themselves to a meet the challenges of a rapidly changing environment.

Fourthly, even if society does provide an environment that generates the trust and enforcement to encourage the formation of collaborative, networked organizations there is nothing about either the trust or enforcement mechanisms that is uniquely applicable to the collaborative, networked organization. These conditions benefit all business and organizations. ~

This collective aspect of the collaborative network causes the social contract to fail not only from a theoretical perspective, but also from a practical point as well. If a social contract did exist between the collaborative, networked organization and society it would be impractical to implement and hence, unenforceable.

Consider the difficulty in answering these questions just to begin implementing a social contract for a collaborative, networked organization. Who are the stakeholders that the collaborative, networked organization has its obligations to? Who is responsible within the collaborative, networked organization for assuring that the obligations are met? How does the collaborative, networked organization demonstrate to its members and stakeholders that it is meeting its obligations? What happens when the membership changes?

Using social contract theory to analyze the ethical and moral obligations of the collaborative, networked organization results in the conclusion that there is not a social contract between the collective members of the collaborative, networked organization and society. In reexamining the Nike example from this perspective it becomes clear that Nike's actions were based on clear strategic business reasons, but any ethical or moral obligation was derived from *its* unique social contract and was not incumbent on it as a member of a collective.

If Social Contract theory fails as a way to understand ethics and morality for collaborative networks is there an alternative? This essay argues that the science surrounding complex adaptive systems may offer that alternative. Rather than being

the result of any social contract, the ethical and moral behavior of a collaborative, networked organization could be said to be one of its emergent properties.

What is an emergent property? Used to describe the features of complex, adaptive systems, emergent properties can be said to be (Goldstein 1999) "the arising of novel and coherent structures, patterns, and properties during the process of self-organization in complex systems. Emergent phenomena are conceptualized as occurring on the macro level, in contrast to the micro-level components and processes out of which they arise." [10].

Stuart Kauffman (Kauffman 1995) describes emergence more simply. "Commonly we express this idea with the sentence, the Whole is greater than the sum of its parts." [11].

Jeffery Goldstein (Goldstein 1999) describes five characteristics of an emergent property. These characteristics provide a test to determine whether the ethics and morality of a collaborative, networked organization are emergent properties. Emergent properties possess:

"**Radical novelty**: emergents have features that are not previously observed in the complex system under observation. This novelty is the source of the claim that features of emergents are neither predictable nor deducible from lower or micro-level components. In other words, radically novel emergents are not able to be anticipated in their full richness before they actually show themselves.

Coherence or correlation: emergents appear as integrated wholes that tend to maintain some sense of identity over time. This coherence spans and correlates the separate lower-level components into a higher-level unity.

Global or macro level: since coherence represents a correlation that spans separate components, the locus of emergent phenomena occurs at a global or macro level, in contrast to the micro-level locus of their components. Observation of emergents, therefore, is of their behavior on this macro level.

Dynamical: emergent phenomena are not pre-given wholes but arise as a complex system evolves over time. As a dynamical construct, emergence is associated with the arising of new attractors in dynamical systems (i.e., bifurcation).

Ostensive: emergents are recognized by showing themselves, i.e., they are ostensively recognized. Bedeau (1997) refers to their ostensive quality when he defines emergence in terms of simulations such as are found in artificial life (Langton, 1986). Because of the nature of complex systems, each ostensive showing of emergent phenomena will be different to some degree from previous ones." [12].

A fairly straightforward analysis of these characteristics quickly determines that four of the five characteristics of emergent properties apply to the collaborative, networked organization's ethics and morality.

Collaborative, networked organization's ethics and morality are certainly dynamic. They evolve either as nodes change their membership or their own ethical or moral activities. Nike's collaborative network is an example of this type of change. The pressure applied to Nike and its network to address working conditions among its partners' operations acted as a strong attractor to pull the entire collaborative network into a new level of behavior.

Collaborative network ethics and morality are observable at the macro level with a certain degree of coherence and correlation. As discussed earlier prosecutors and society can make decisions about whether or not a collaborative network is

collectively criminal. This implies that collaborative networks collectively possess observable macro level ethical or moral behavior that last long enough to lead to prosecutorial decisions being made that apply to the whole organization.

The collective ethical and moral behavior of a collaborative network is ostensive because until the organization is formed its behavior is not apparent. And there is no guarantee that if the same network reforms that the same behavior would emerge.

The challenge in deciding whether ethics and morality is an emergent property is whether collaborative, networked organization ethics and morality are radically novel. Goldstein argues that radical novelty is neither predictable nor deducible from the nodes before the emergence.

While it is correct that collective ethical and moral behavior cannot be absolutely predicted based on the individual nodes' ethical and moral behavior, its *probability* could be determined based on the past behavior of the individual nodes. At the same time the complexity of the collaborative network's ethics and morality, its "full richness", cannot be anticipated until it emerges.

This leaves open the question of how high the probability exists that a collaborative network will exhibit ethical and moral behavior that is not the sum of its parts. And it is probability's presence that weakens the case for ethics and morality being an emergent property. Because it cannot be said to be an absolutely radical novelty, collaborative ethics and morality could be said to be moderately emergent property.

Viewing ethics and morality from an emergence perspective reveals that as each node within a collaborative, networked organization enacts its unique social responsibility to meet its unique ethical and moral obligations, the collaborative, networked organization's ethics and morality becomes apparent. Like the formation of birds in flight, the formation is the result of individual actions caused by each bird.

This approach addresses the problems of using social contract theory to identify collaborative networks' ethics and morality by identifying it as an attribute of the network instead of a behavior. Trying to identify the benefits and obligations between society and the collaborative network is not necessary. The practical implications of identifying such a social contract are not applicable. The collaborative network's ethics and morality simply *are*.

4. ORGANIZATIONAL RESPONSES TO ETHICAL AND MORAL ISSUES

If the ethical and moral obligations of collaborative, networked organizations are emergent attributes or properties then what are the implications for the broader field of business ethics and how collaborative networks respond to those issues? This question has a serious practical application since it leads to the question of whether the effort spent trying to identify and codify the obligations incumbent on the collaborative, networked organization might be better spent in describing the attributes of such an ethical and moral organization.

Because of the myriad scandals and protests over business behavior an increasing number of firms and organizations are now working diligently to develop

global paradigms of business ethics and morality. This effort may stem from a perception that the business will benefit from an enhanced image, or the actions may result in a competitive advantage. Regardless of the reason the effort is underway and growing. Donaldson (2000) has shown that business and society is developing two main methods to accomplish this: creating and enforcing codes and compliance mechanisms and creating and publishing identity and values statements [13].

Code and compliance mechanisms have been the focus of most organized activity and the most common effort. These mechanisms rely upon a clearly defined set of standards to direct and enforce the behavior of the business and its employees. These codes may be internally generated, generated from the industry or trade (such as within the financial service industry) or by 3rd party groups such as the UN or OECD (e.g. the Global Compact). These range from formalistic documents, often written by lawyers, to simpler process descriptions such as the Copenhagen Charter. Regardless of the style the goal of these mechanisms is the same. They seek to impose clearly defined obligations on managers, workers and suppliers that can be referred to in a written document which provides a basis for enforcement and verification.

Alternatively, Identity and Values Statements are undertaken by individual organizations. These are often espoused by companies in their annual reports and web-sites or as supplements to their other reporting. These statements attempt to establish the "personality" of the business by articulating the company's ethical and moral foundations and the actions it performs to meet its obligations as it sees them. The higher concept is that publishing such statements the company can influence, in a non-direct way, the behavior of employees and partners.

However each method is troubled. Codes and compliance attempts show little correlation to improved business ethics. Those that do seem most effective tend to be voluntary mechanisms created by individual companies rather than efforts developed by committees. In addition, transnational business confronts the challenge of differing local ethical systems and moral beliefs. Those trying to create a global code or compliance mechanism face the challenge of reconciling these differences.

Without a clear connection to the business activity Mission and value statements are often window-dressing designed to communicate a pleasant image. Indeed the lack of any generally accepted form or method to construct and verify such statements is one of their key weaknesses.

While these efforts have challenges, it does not mean that they should be stopped. These should continue since they are part of the ongoing renegotiation of the social contract between individual companies and society. However if ethical and moral behavior is an emergent property of the collaborative network, then efforts to prescribe codes and compliance standards or create mission and value statements for the collaborative network doesn't make sense.

More effective, from an emergent property approach to understanding these ethical and moral issues, would be to try and identify the attributes of an ethical and moral collaborative network. Such identification would provide a better framework to identify those collaborative networks that act in generally perceived ethical and moral manners.

Such an idea has precedence in the work of Donaldson and Dunfee (2000). Specifically addressing challenges to Social Contract theory when applied to

transnational companies, they developed the idea of "Integrative Social Contract Theory". As they state: "ISCT does not overturn popular wisdom. While it asserts that the social contracts that arise form specific cultural and geographic contexts have legitimacy, it acknowledges a limit to that legitimacy. It recognizes the moral authority of key transcultural truths, for example, the idea that human beings everywhere are deserving of respect." [14].

Core to this idea is the concept of hypernorms that could describe such attributes: "Hypernorms are principals so fundamental that they constitute norms by which all others are to be judged. Hypernorms are discernable in a convergence of religious, political and philosophical thought" [15].

Hypernorms allow the widest possible boundaries of ethical and moral behavior by an organization that crosses cultures. It provides a company with the freedom to adapt these hypernorms to meet local conditions without having to worry about reconciling the differences. In fact such an idea anticipates potential differences at a local level. From an emergent property perspective the idea of hypernorms helps solve the issue of describing the ethical and moral behaviors of a collaborative network.

One practical example of such hypernorms is seen within the United Nations' Global Compact. This document identified what it refers to as nine "Global Contract Principals". The purpose of the Global Compact is "to encourage an alignment of corporate policies and practices with universally agreed and internationally applicable values and goals. These core values have been distilled into nine key principles in the areas of human rights, labour and the environment..." [16].

The Global Compact does not view itself as a code or compliance standard. Rather its purpose is to encourage and promote the adoption of these nine principals within business organizations. In this example, and within the concept of hypernorms, lie the seed to begin describing the emergent attributes of an ethical and moral organization.

5. CONCLUSION

As business increasingly participates in collaborative, networked organizations what does this mean for understanding their ethical and moral obligations? This essay examined traditional methods of understanding business ethics and morality. The rise of collaborative networks challenges this traditional method and the understandings associated with it.

From the science surrounding complex adaptive systems a potential alternative to traditional understanding of business ethics and morality we developed. This alternative is that business ethics and morality, from a collaborative network perspective, is best viewed as an emergent property of that system.

As emergent properties the way each individual participant responds to their unique obligation eventually affects the ethics and morality of the collaborative network. Therefore how individual business responds, and how that might change as a result of participation in collaborative networks, is of crucial importance to further the understanding the practical implications of the ethics and morality of collaborative networks.

Current efforts to renegotiate the social contract between business and society focus on the individual node. These efforts are challenged when applied to cross-cultural environments. In addition if collaborative network ethics and morality are emergent then the applicability of these efforts to collaborative networks is problematic at best. An alternative is to instead try and describe the emergent attributes of an ethical and moral collaborative network.

Two examples of such an effort, one theoretical and the other practical, were examined. The theoretical concept of hypernorms, while derived from Social Contract theory, holds great promise as one way to describe emergent attributes. The UN's Global Compact provides a solid example of how such hypernorms might be expressed.

This essay began by referring to several recent confrontations about business ethics and morality. It explained how economic development can be seen as an ongoing conflict and resolution of differences about ethics and morality. As the world continues this never-ending process it must develop an understanding of how new forms of organization will affect that process. Viewing collaborative network ethics and morality as an emergent property offers one potential method to developing that understanding.

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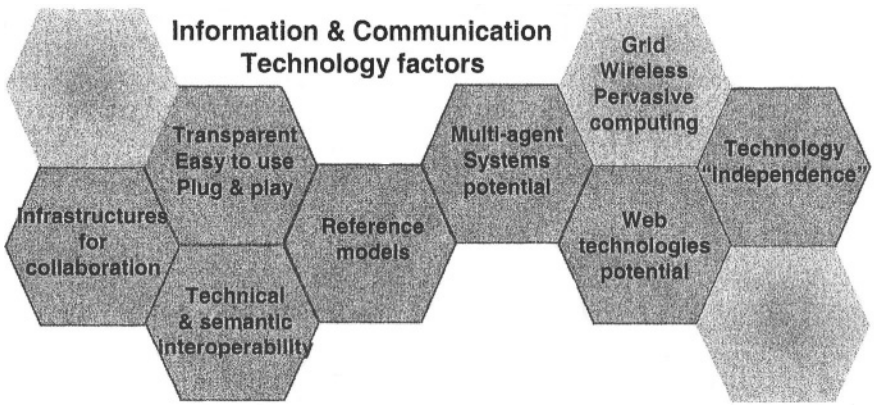
INFORMATION AND COMMUNICATION TECHNOLOGY FACTORS

5.1 OVERVIEW

This part is devoted to the Information and Communication Technologies and their role in supporting collaborative networks. The first chapter addresses and clarifies the role of ICT infrastructures and support services. It presents a summary of the main approaches and open research challenges in development of horizontal infrastructures and support services for the virtual organizations, the breeding environments, the professional virtual communities, and the e-science. The following chapters further focus on the most promising technologies, their status and limitations. In particular, multi-agent technologies, grid computing, web services, virtual private networks, mobile and pervasive computing, and related standards are addressed.



Specific research needs are identified in each chapter and detailed recommendations are provided. At a more macroscopic level the following messages are conveyed:

- Advanced infrastructures for collaboration are the major requirements for the wide deployment and effective management of CNOs. The infrastructures must be easy to use and support plug-and-play services for the life cycle of the VOs and other forms of CNOs.

- Reference models need to be defined for support infrastructures of collaborative networked organizations, providing the framework for technical, organizational, and semantic interoperability. This reference model must be as much technology-independent as possible and include design principles and guidelines, multi-level support for interoperability, reconfiguration and recovery mechanisms, multi-level security and auditing facilities, among others.

- Multi-agent technology constitutes a promising contributor to the development of support infrastructures and services for CNOs. An active involvement of the CNO community with FIPA standardization activities is required in order to facilitate the development of proper robust MAS platforms to be used in a CNO.

- The so-called Internet and web technologies, namely in the area of web services, represent a fast growing sector with large potential in inter-enterprise collaboration support. Nevertheless, most of current developments are too focused on simple B2B transactions, while CNOs require further developments in terms of supporting multi-party collaboration (coalitions).

- A number of other emerging technologies e.g. grid, wireless communications, pervasive computing, location-aware and situation-aware environments for mobile users, are likely to provide important contributions to enable more advanced models of collaboration and shall be closely monitored and assessed by CNO researchers.

- Public funded research should avoid approaches that are too-biased by existing technologies, that mostly appear and disappear at a fast speed, and must rather focus on long-term breakthroughs. However, the prototype developments and proof of concepts certainly requires mapping the logical architectures into existing technologies. Therefore researchers need to monitor and recognize the main trends and more promising technologies, but the choice of technology should not preclude research programs, keeping them from a clear focus on the strategic long-term developments.

SUPPORT INFRASTRUCTURES FOR NEW COLLABORATIVE FORMS

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Large-scale implantation of advanced collaborative networks depends on the availability of transparent, easy to use and affordable "plug-and-play" ICT infrastructures. In spite of the fast progress of the so-called Internet technologies, a large number of challenges still remain open, both at the level of the horizontal infrastructures and the support services required for various types of collaborative forms.

1. INTRODUCTION

Design and development of transparent, easy to use, and affordable "plug-and-play" ICT infrastructures, is a key pre-requisite for the effective large-scale implantation of collaborative networks such as advanced virtual enterprises (VE) / virtual organizations (VO).

When discussing the role of ICT in VO/VE it is important to distinguish between the (horizontal) infrastructure and the (vertical) support services (Fig.l).

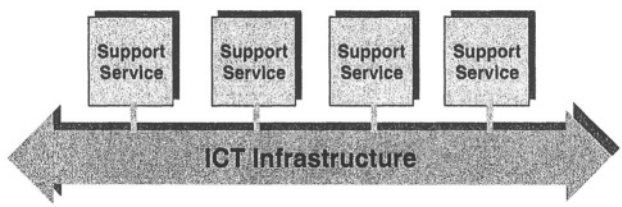

Figure 1 – ICT infrastructure and support services

The ICT infrastructure plays the *intermediary* role as the **enabler of interoperation** among organizations and the support services provided and involved in the VO. It is the base enabler for safe and coordinated interactions among the VO members. In other words, it plays the role of a **VO "operating system"** or executor, **hiding the details** of the collaborative network "machinery" from the users and application programs. **Support services** consist of a set of vertical application tools that will be plugged into the horizontal ICT infrastructure.

Availability of a large number of contributing elements, e.g. advanced

technologies, innovative paradigms, and best practices and models, constitutes a set of facilitating factors. The main factors include: the information and communication technology research advances: Web technology, standards and tools, communication security, federated information management, coordination theory and systems, component-based system design and developments, MAS technology and software mobility, GRID technology, mobile computing, knowledge representation, with particular focus on shared ontologies and imprecise knowledge representation / soft-computing, etc. Today these factors and others provide the opportunity and required base for materialization of necessary concepts and mechanisms that although are not new, were waiting for their proper enabling factors. Examples of such concepts and mechanisms that can now be developed as software tools and software environments include:

- Related to the development of VE / VO platforms, significant developments are required to support infrastructures, various experiments in regional clustering / networking, and various pilot cases of ICT supported clusters can now be designed and developed.
- Related to spreading and widening the acceptance of the concept of "sharing" in software environments: Computational resource sharing through GRID, collaborative engineering, the Virtual Laboratories (VL), P2P-ERP/PDM Systems for dynamic SMEs, contracts and negotiation models for sharing (acquaintance models, auctions, etc.) have now the necessary base to materialize.
- Related to new collaborative organizational design, including structure and processes, and interactions with the environment, similarly the base is now available to build them.
- Related to virtual communities, basic technologies and tools can now support the establishment of professional communities.

Furthermore, many new generation devices will have small, inexpensive processors with limited memory and little or no persistent storage. They will connect to other computing elements without the direct intervention of users. Often, wireless networks will connect them. They also physically change their configuration rapidly, sometimes by being mobile, sometimes by going on- and off-line at widely varying rates. Over time, they will be replaced (or fail) far more rapidly than is now common. Sensors and machine components may become intelligent and used as a source of information, or become resources frequently sending that information into the network to which they are attached. The surrounding environment (Ambient Intelligence) will be composed of distributed processing units that interact with every other computer, joining its vital space, going beyond the WAN / LAN concepts to the BAN - Body Area Network - and PAN - Personal Area Network – concepts, resulting the generalization of ubiquitous or **pervasive computing**.

The emergence of a large and growing number of standards and technologies could represent potential enabling factors, sometimes leading to the myth that "all technology related problems for VOs are solved"! However, most of these technologies and concepts are in their infancy and under development, mostly fragmented and non-interoperable, requiring considerable effort to implement and configure comprehensive VO support infrastructures and operational methods.

Even the most advanced infrastructures generated in leading R&D projects,

require complex configuration and customization processes hardly manageable by SMEs. Although not all projects aim at developing horizontal infrastructures, the lack of a common and widely accepted **reference model** and reference architecture is forcing almost every project to design and implement its own mini-infrastructures, deviating some resources from its main focus, while generating something only applicable to that project.

At the same time, although it is not a new subject rather the central focus in systems integration, **interoperability** still remains as a critical topic in the agenda of VO supporting infrastructures research. Furthermore, the fast evolution of ICT technologies with reduced life cycles and the need to cope with technologies that themselves on one hand have different life cycles and on the other hand, each one is at different stages of maturity in relation to its life cycle, represent a major difficulty. There is therefore a need to discern between enabling and disabling technologies. The fact that some VO related efforts are too biased by short-term technologies, might in fact represent an obstacle for non-ICT SMEs. Therefore, in order to leverage the potential benefits of the collaborative networks paradigm, more **flexible and generic infrastructures** need to be designed and implemented.

Furthermore there is a need for development of mechanisms to empower human relationships as a way to induce creativity, to strengthen cohesion and sustainability, and to reach responsiveness to market turbulence. Similarly, the developments in this area are still **mostly technology-driven** and achieved independently of each other and at different projects; thus repeatedly providing only very primitive *interaction infrastructure* among the organizations involved in the VO.

Understanding the emerging behavior of collaborative networks and trends (how and why) is a challenge, requiring further developments in modeling, support mechanisms and tools (support services), coordination principles and leadership, and establishment of collaboration support (virtual) institutions (e.g. e-notary, e-dispute-solving). Similarly there is a need for planning and establishing new **integrated** metrics. Dynamic evaluation of the fractional value of processes (e.g. value features, rewarding principles, creation of enterprise-wide appreciation of new value features, trust arbitrators, auditability), need to become part of a comprehensive research and development initiative.

In terms of research projects, Fig. 2 classifies and briefly identifies the various levels of infrastructures that have been identified by different literature to support not only inter-enterprise collaborative networks but also human-oriented networks, i.e. professional virtual communities and virtual research communities that can emerge in the context of a VE/VO [7].

The "typical" VOs and VEs have been firstly focused on the basic interaction infrastructures to support business collaborations, including: safe communications, distributed information management and information sharing (eventually using specific standards such as EDIFACT, STEP), coordination, and minimal distributed business process management, with little focus on the human collaboration.

The second level of infrastructure is mostly dedicated to support collaboration among humans, although some of the projects also consider the organizations behind the professional virtual communities. Examples are the support for the case of Concurrent / Collaborative Engineering in networked organizations, networks of consultants, and other professional virtual communities.

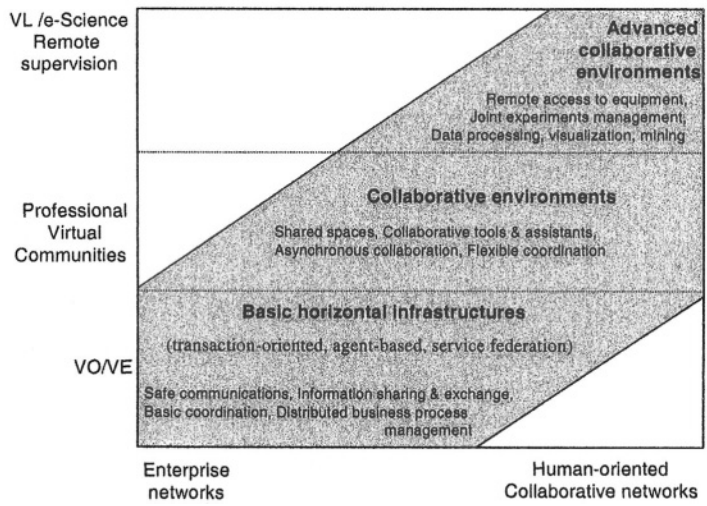

Figure 2 – Main classes of VOs and corresponding infrastructures

The third level is focused on a specialized human collaboration. It combines both inter-organizational and human collaboration, but including the access to remote equipments (e.g. machines, sensors, equipment for scientific experiments), collaborative experiments involving both the teams located close to the equipments and teams located remotely.

In this context this chapter summarizes the conclusions of discussions in the framework of THINK*creative* regarding the required developments in ICT infrastructures [4], [8]. Following sections discuss major aspects in VO, including: infrastructures, cluster management and VO creation, VO operation, evolution and dissolution, virtual communities, and virtual laboratories, including some brief references to the necessary agility of the shop floor of manufacturing companies. For each of these topics, a brief overview of the state of the art and major trends is presented, followed by a list of suggested key topics for further research.

2. HORIZONTAL INFRASTRUCTURES FOR VO

As mentioned above the ICT horizontal infrastructure is usually aimed to play an *intermediary* role as an enabler of the interoperation among components [9]. Namely, in this context it is intended as the enabler for safe and coordinated interactions among the members of the collaborative network. Furthermore, and from another perspective, the integrating infrastructure should play the role of VO "operating system" or executor, hiding the details of the collaborative network "machinery".

So far, three main approaches have been followed in the development of horizontal infrastructures for VO/VE:

a) Layer-based or transaction-oriented approach, which adds a cooperation

layer to the existing IT platforms of enterprises. Inter-enterprise cooperation is then performed via the interaction through these layers [4], [17].

b) Agent-based approach, including the cases that represent enterprises as agents and the inter-enterprise cooperation as interactions in a distributed multi-agent system [6], [12].

c) Service-federation / service-market approach - according to which, enterprises publish their services in service directories, representing their potential "offer" to the cooperation processes. By means of proper "standard" service interfaces, the interoperability with other (service requesting) enterprises is supported, regardless of the heterogeneity associated with the actual implementation of the services themselves [5].

A large number of projects have followed one of these approaches. Nevertheless it is important to notice that approaches b) and c) in fact represent higher abstraction levels in comparison with the approach a). However, all of them need as the base the essential components of safe communications, distributed information management, and coordination that are first addressed and introduced by the transaction-based approach.

In terms of practical application, the approaches a) and c) are those most used at the current stage. Multi-agent approaches, although presenting a high potential also reflected by the large number of research projects adopting this paradigm, still suffer from lack of robust MAS platforms for operation over the Internet environments.

In parallel to the VO research, another area researched by the Grid community introduces new concepts for base infrastructure, focused on resources sharing, for which their suitability to the VO needs has to be evaluated.

Suggested research topics. Setting up an infrastructure for VO/VE still requires a large engineering effort, which represents a major obstacle for the implantation of this new organizational paradigm. Furthermore, it shall be noted that the fast evolution of the information technologies often presents a disturbing factor for non-IT companies. Therefore, further research effort is necessary towards the establishment of generic and interoperable infrastructures.

Some open research issues include:

- Design principles and guidelines for technology-independent reference architecture.
- Advanced federated information management, supporting the authorized information exchange, information integration mechanism, and collaborative work among organizations.
- New approaches to interoperability addressing the following issues: (i) Interoperability needs continuous adjustments, as new technologies are emerging every day, (ii) Interoperability should be treated as a "design principle" in software systems development, (iii) Diversity / heterogeneity / autonomy of components must be accepted (not avoided), (iv) Co-existence of components with different life cycles and in different stages of their life cycles must be assumed, (v) More effective integration of legacy systems is

necessary.

- Progress towards an invisible, pervasive, and plug-and-play support infrastructure.
- Inter-domain transactions and transaction recovery mechanisms.
- Generic security framework, providing configurable and dynamic multi-level security architecture and mechanisms.
- Tracking and auditing support services. Also self-identification (of products), allowing traceability and closing the gap between the physical world and the logical world.
- In parallel with technical developments, and in order to facilitate wide availability, new business models for horizontal infrastructures and characterization of the relevant stake holders, need to be devised.
- As a more long term objective, research on "configure yourself" infrastructures shall proceed in order to provide advanced configuration mechanisms, context-adapting, semantically-informed, and self-organizing infrastructures.
- Progress on robust MAS (Multi-Agent Systems) support platforms and their integration in the enterprise legacy systems.
- Assessment of emerging infrastructures developed in other areas, e.g. Grid, pervasive computing.
- Development of e-services, oriented towards collaboration. Most developments so far had a "transaction-oriented", and not a "collaboration-oriented" perspective.

3. BREEDING ENVIRONMENTS AND VO CREATION

Early projects and proposals, too much technology-driven, underestimated the difficulties of Virtual Organization creation process and suggested very dynamic scenarios, while the agility and dynamism required for VOs are limited by the difficult process of building trust and establishing cooperation principles. Even if flexible support infrastructures become widely available, the aspects of trust building and the required reorganization at the enterprise level are hard to cope with in cooperative business processes. "Trusting your partner" is a gradual and long process. Definition of "cooperative business rules", contracts for VOs, and common ontologies are challenging, especially when different business cultures are involved. In this sense, very dynamic organizations formed by enterprises without previous experience of collaboration might be limited to scenarios of simple commerce transactions (e.g. buy-sell).

The creation of long term clusters of industry or service enterprises represents an approach to overcome these obstacles and can support the rapid formation of VO inspired by business opportunities. The concept of cluster of enterprises, which should not be confused with a VO, represents an association or pool of enterprises and related supporting institutions that have both the potential and the will to cooperate with each other through the establishment of a long-term cooperation agreement. Buyer-supplier relationships, common tools and technologies, common markets or distribution channels, common resources, or even common labor pools are elements that traditionally bind the cluster together. The more frequent situation

is the case in which the cluster is formed by organizations located in a common region, although geography is not a major facet when cooperation is supported by computer networks. Nevertheless, the geographical closeness has some advantages for cooperation, as it may facilitate better adaptation to the local (cultural) needs and an easier creation of a "sense of community". But with the development of more effective communication infrastructures, such long-term associations are not necessarily induced by geographical closeness. Cultural ties, even particular human relationships are also motivating factors to form such associations which in fact represent the VO **Breeding Environments** (VBE) for the dynamic formation of VOs [9].

Industry clusters do not correspond to a new concept as a large number of related initiatives have emerged during the last decades, namely in Europe and the USA. But the advances in information and communication technologies now bring new opportunities to leverage the potential of this concept, namely by providing the adequate environment for rapid formation of agile virtual organizations. If long-term collaborative environments or business ecosystems are in place, it is viable to establish **dynamic VO/VE** as a rapid and optimized response to business opportunities and threats. For each business opportunity found by one of the VBE members, acting as a **broker**, a subset of the VBE enterprises may be chosen to form a VO for that specific business opportunity [13].

It is important to notice that there is a potential conflict between fast innovation and the stability requirements that are both part of the human nature. It is necessary to find harmonic solutions to conciliate the dynamism of the new business ecosystems and the needs for stability of individuals (and their families). New concepts and supporting institutions for life support and "life maintenance" can emerge in the context of a breeding environment.

From a regional perspective, a well-managed VBE may offer the opportunity to combine the necessities of both "old" and "new" economies, and form a sustainable environment (local business ecosystem) while leveraging and preserving the regional assets and culture. The VO breeding environment can support the exploitation of local competencies and resources by an agile and fast configuration of the most adequate set of partners for each business opportunity. Furthermore, the local VBEs can gather and empower a unique set of competencies tailored to regional culture and local customers' preferences, allowing a concerted offer of cooperation to global companies. As a result, members of the local industry cluster for instance can play an important role in the customization and final assembly of products to local markets even though the basic components may be produced elsewhere. Therefore, in times of tough competition and market turbulence, the organization and effective management of the local industry or service enterprises, VBEs focused on the characteristics of SMEs, provide a promising approach for regional sustainability.

Fig. 3 illustrates two approaches to build a virtual organization – with (in 1a, 1b) and without (in 2) a breeding environment. In the case of using a breeding environment the steps represented in la were performed beforehand, i.e. during the establishment of VBE and when new members join the VBE, and with a prospect of long-term collaboration. As such, when a business opportunity is found, only steps represented in 1b need to be performed, what leads to a much faster response in

comparison with the path represented in 2.

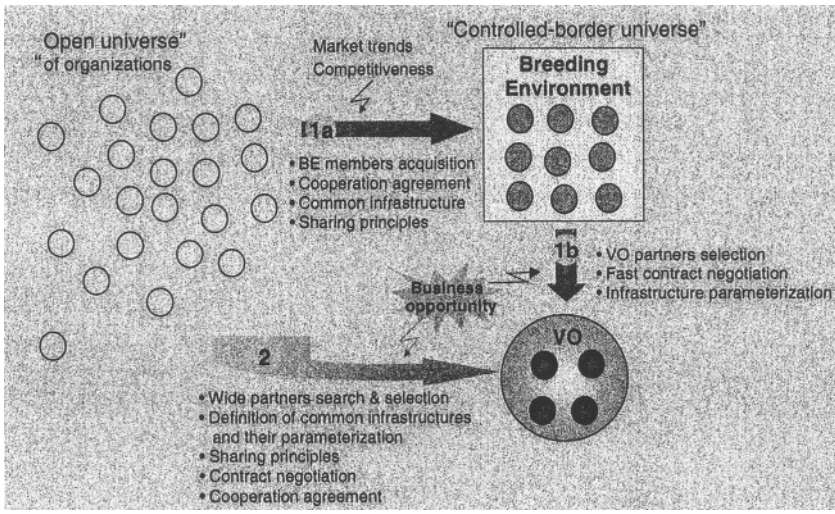

Figure 3 - Two approaches for VE formation

One of the problems in the partners search process for VO creation is the availability of directories of companies / organizations where their profile (skills, resources, performance history, etc.) are represented in a standard format. Unavailability of a standard to represent these profiles has been a major obstacle. Recent developments in the area of e-services (UDDI, WSDL, SOAP) represent promising steps in this direction. Nevertheless if the catalog is confined to a cluster it is easier to reach a common representation of profiles.

Some ***open research topics*** in terms of ICT support for this area include:

- Full characterization of generic breeding environment models and base mechanisms.
- Management and configuration of breeding environments operating on specific vertical markets with specific business processes requirements.
- The full VO creation framework, including VO planning and launching, brokerage and partners' selection, contract negotiation, and VO operating rules definition.
- E-notary and certification services for networked organizations with special services such as: black lists, past performance, credentials, and best practices.
- Design, modeling, and evaluation of other support *institutions* for advanced collaborative forms (e.g. new life maintenance institutions, conflict resolution institutions, competence accreditation institutions) and their ICT requirements.
- Modeling and management of cooperation contracts and agreements.
- Inter-VO transactions, allowing for smooth transition among the various VOs that might be involved in a product/service life-cycle.
- Management of VO inheritance (knowledge, liabilities, benefits that remain

after the VO dissolution).

- Methodologies for transforming existing organizations into VO-ready organizations.
- Exploitation of synergies among breeding environments, VOs, and professional virtual communities.

4. VO OPERATION SUPPORT

Coordination of distributed business processes (DBP) and activities is an important element of the VO operation. Most of the early approaches took a workflow-based approach, starting with the WfMC reference architecture [16] and experimenting with extensions for supervision of distributed processes (cross-organizational workflow) including some preliminary but very limited work on exception handling, multi-level coordination and its relationship to coordination roles of the VO members, and flexible workflow models to support less structured processes.

In terms of DBP planning and modeling some graphical languages have been suggested but a standard is still necessary in order to allow effective distribution / sharing of business processes. Proposals like PIF and PSL have been discussed but there is still more work to do. A recent European initiative, the UEML network, also contributed to the discussion of the harmonization issues in the modeling area.

In terms of business support functions, most of the projects have addressed application specific cases. ERP vendors have been extending their monolithic single-enterprise-centric systems in order to comply with more dynamic supply chains and networks, but this is an area requiring more investment on extensions towards the collaboration among enterprises, as well as development of generic functionalities.

Some ***open research topics*** on VO operation support include:

- Modeling, coordination, administration and management of highly distributed activities, tasks, processes, and roles. Planning and supervision (enactment, monitoring, diagnosis, error recovery, and performance measurement) of distributed processes (including complex services).
- Risk management / assessment tools.
- Design, development, provision and management of value-added services (generic e-services: logistics, CRM, procurement, etc.) provided in the context of VE/VOs.
- Dynamic evaluation of revenues, rights and liabilities related to both activities and every VE/VO relationships.
- Dynamic selection of new partners in order to make the VE/VO network more effective.
- Clarify / re-define notions of value in a society of relationships, focusing on the added-value contribution (how to measure it?) of each node and how to reward it in order to preserve the business ecosystem (dynamic sustainability concept). What is valuable, where does the value reside, who generates value? Cooperation adds an overhead to the normal operation of companies that has to be compensated by the added-value and agility.

- Soft-modeling and reasoning with special decision support mechanisms for supply chain management, efficiency of VE/VO relationships.
- E-contract management and adaptation to the legal frameworks.
- Advanced simulation models and tools for networked collaborative organizations, and how to reflect the results on the decision making process at the VE/VO level.
- New business support functions and models, and their better integration with enterprise applications.
- New user interfaces exploring ubiquitous computing trends, and seeking an entertainment facet as a way to overcome cultural barriers.

5. VO EVOLUTION AND DISSOLUTION SUPPORT

During the life cycle of a VO it is natural that some partner may leave the consortium and needs to be replaced by a new organization. The termination of this collaboration process or even the ending of a VO, are subjects not properly addressed yet.

The consequences of the operation of a VO/VE cannot be simply discarded when the VO/VE dissolves. Most of these consequences are of a legal nature and shall be regulated by the cooperation agreements. That is the case, for instance, of the responsibility of customer support / product maintenance during the life cycle of the product / service generated by a VO/VE. Environment regulations are also forcing companies to plan provisions regarding the product disposal and recycling after its end of life.

Recent regulations in some countries also state that the liabilities regarding each component of a product may ultimately lie with that component's supplier. In the case of a network chain type of manufacturing this forces each node in the chain to keep track of the history of each component/sub-product that has "passed through" this node. This is a functionality that is properly supported by most of the more advanced ERP systems, but not by most of the scheduling systems, for instance.

There are however, several other less tangible issues which are more difficult to handle. One of these issues is the Intellectual Property Rights (IPRs) policy, namely for the post-dissolution phase and for instance its consequences in terms of information accesses by the VE members. In some cases there is also the possibility that the VE evolves into a more permanent organization, a joint venture enterprise created by the VE members, to exploit the intellectual and industrial property results developed in cooperation. There is also considerable knowledge that can be elicited from the ending cooperation experience, namely the knowledge about what went right, what went wrong, partners performance / reliability, jointly defined business process templates, etc. Defining the ownership and access rights to this knowledge is not an easy task and requires further investigation.

Therefore, some important ***research topics*** include:

- Definition of a legal and organizational framework for the termination of a cooperation process.
- Creation of mechanisms for handling post-cooperation IPRs and liabilities,

i.e. VO inheritance management in order to handle the results of the VO operation (generated knowledge, devised practices, products / services).

- Management functionalities to support the post-VO access to common resources and information.
- Mechanisms to support extensive traceability after VO dissolution.

6. PROFESSIONAL VIRTUAL COMMUNITIES SUPPORT

A Professional Virtual Community (PVC) represents the combination of the concepts of virtual community and professional community. Virtual communities are understood as social systems of networks of individuals, who use computer technologies to mediate their relationships. On the other hand, professional communities or communities of practice provide environments for professionals to share the body of knowledge of their professions such as similar working cultures, problem perceptions, problem-solving techniques, professional values, and behavior. When professional communities adopt computer networks and most of the practices and tools of virtual communities, they become professional virtual communities.

In fact, when a proper cooperation breeding environment (e.g. cluster or long term network) is in place, professional virtual communities / virtual teams may emerge within such environment, constituting a fundamental element of value creation and sustainability. Virtual communities and communities of practice are not new concepts but they provide the necessary base and play an increasingly important role when considered in the context of the collaborative networks of organizations. These communities, although can be spontaneously created, are bound to certain social rules, resulting from the commitment of their members to the underlying organizations; thus representing the new concept of socially-bound PVCs (Fig. 4).

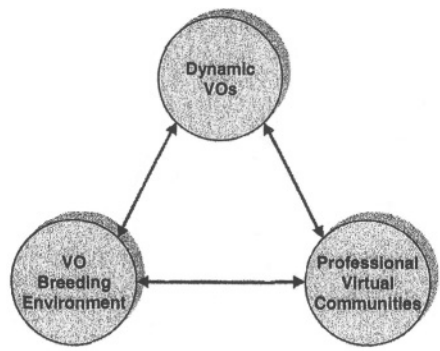

Figure 4 – PVCs in the context of VOs and breeding environments

This is the case, for instance, in the *concurrent* or *collaborative engineering* area where teams of engineers, possibly located among and contractually bound to different enterprises, cooperate in a joint project such as the co-design of a new product.

A large number of computer supported cooperative tools are becoming widely available for synchronous cooperation among people. Some examples are

teleconference and chatting tools, combined with application sharing mechanisms. Considering the geographical distribution, the autonomy of the VE members, the local corporate cultures, and also the individual working preferences of the team members, it is likely that most activities will be carried out in an asynchronous way.

In terms of coordination, several approaches to develop *flexible workflow* systems have been proposed. In the case of processes mainly executed by humans, rigid forms of procedural control are not adequate. People like to keep their freedom regarding the way they work. Product design, like any other creative process evolves according to a kind of "arbitrary" flow. It is therefore necessary to also support *loosely constrained* sets of *business processes.*

This trend is followed by other communities of professionals (e.g. consultants) that share the body of knowledge of their professions such as similar working cultures, problem perceptions, problem-solving techniques, professional values, and behavior. Another special area of application, as for instance represented by the TeleCARE project [7], is the creation of virtual communities for providing care services to elderly. These communities involve organizations and people such as care providers, health care professionals, relatives of elderly, and the elderly.

Some open ***research topics*** in supporting ICT for PVC include:

- Definition of collaboration models and practices.
- Development and management of shared, smart spaces for geographically distributed teams of the same or different organizations, which develop complex engineering products (advanced collaboration spaces).
- Provision of adequate visibility and access rights definition and management.
- Reliable members' identification and members' profiling.
- Understand and model multi-level relationships among VC members.
- Coordination of (asynchronous) activities performed in different places by different actors; flexible coordination models. Multi-modal collaboration spaces.
- Development of frameworks for collaboration in mobile contexts.
- Tools for community management, leadership, and creation of incentives.
- Provision of notification mechanisms regarding major events during the design / planning process (e.g. notification of conclusion of a step by one actor).
- Collaboration measurement, certification and rewarding. Mechanisms to handle Intellectual Property in VCP under social contracts.
- Collaborative problem solving methods and support tools, including collaborative decision making, brainstorming, argumentation and synthesis methods and tools.
- Business models and support tools for PVC exploitation. Life maintenance institutions for e-lancers.
- Exploratory collaborative spaces based on new approaches from IT, cognitive and social sciences: avatars, virtual reality, link discovery, evolving roles and community governance principles, and intelligent agents.

7. e-SCIENCE AND REMOTE SUPERVISION SUPPORT

E-science and virtual laboratories represent another class of collaborative networked organizations.

A Virtual Laboratory (VL) represents a heterogeneous and distributed problem solving environment that enables a group of researchers located in different geographically spread centers to work together, sharing resources (equipments, tools, data on experiments, etc.), namely forming a specific and specialized PVC.

In some domains requiring expensive equipment and a large critical mass of researchers, e.g. in bio-informatics, there is a pressing need for enhanced environments to assist researchers with conducting their complex scientific experiments. Another application scenario for VL requiring specific support tools is the remote education focused on e-learning.

VL can benefit from the integration of results and approaches generated in related areas such as tele-operation / tele-supervision, federated information management, and collaborative spaces, among others, and involves:

- Interaction between people, instruments, and information, supported by:
  - Collaboration tools: teleconferencing, chat, shared e-whiteboard, notepad, etc.;
  - Remote access to scientific instruments connected to the collaborative network;
  - Sharing and authorized exchange of information among collaborators;
  - Large scale simulations;
  - Data filtering and data reduction facilities; and
  - Visualization tools and devices.
- Remote experiment execution and control.
- Access to information from distributed public and proprietary sources.
- User-friendly interfaces.
- Integration/fusion of distributed and diverse meta-data, data, and results.
- High-performance, secure, distributed and collaborative experimentation environment.
- Semi-intelligent assistance to define and perform experiments.

During the last years, research and development projects have focused on the development of enhanced support infrastructures (horizontal base) for VLs. However, these only constitute specialized areas of science, e.g. supporting astronomy or special areas of biology research. Only during the last five years, a small number of projects have considered infrastructures supporting multi-disciplinary scientific experimentations and with the focus on merging federated information management supporting information visibility / access rights, massive / parallel processing, provision of resource sharing on one-of-a-kind expensive instruments, and a set of assisting software tools for simulation, visualization and data analysis. Most of these VL developments are still only supporting problem solving within a centralized laboratory node that can be accessed remotely by scientists.

Out of these R&D efforts, only a few have focused on providing steps within a real distributed problem-solving environment, using Grid environment as the base.

The next step for research on virtual laboratories' infrastructures calls for its extension with the support for collaboration among the involved organizations, setting up procedures for sharing / exchange agreements, common ontologies, and contract negotiations, among others.

A more recent area of work – e-science – is extending the virtual laboratory research. e-Science is in principle concerned with the provision of electronic support environments for different organizations to collaborate with their experimentations. As such, e-science combines the facilities supporting the VOs to the virtual laboratory environments.

In a related area, tele-robotics and remote supervision, the use of networking and the Internet have been progressively increasing for a wide domain of applications, e.g. remotely operated robots and telescopes, manufacturing systems, virtual laboratories, etc. The traditional approaches taken in this area assume a set of pre-defined services which a user can activate on simple machines and sensorial remote environments. However, if complex machinery or sensorial environments are considered to be remotely operated with maximum flexibility, a set of pre-defined services and simple monitoring/recovering procedures are not sufficient. Also, for large or variable time-delays and low availability of the communication channels, remote low level closed loop control is impractical and higher levels of control, such as supervisory control, for example, and autonomy are required. Therefore, more sophisticated and more reliable solutions have to be found leading to an increase of the autonomy of the equipment being operated, yet preserving a high degree of flexibility. One promising approach consists of applying intelligent mobile agents [15]. Adaptable agents, carrying high level missions, can adapt themselves to the available resources in the visited places, allowing for a higher autonomy namely in the case of a temporary unavailability of network connections. Agents can also provide a facility to implement assistance mechanisms and to support asynchronous cooperation. But this process may assume more extensive forms. Consider the case that a company wishes to "open a window" over the shop-floor of its partner to monitor the manufacturing process of the ordered parts and even have an interference on the shop-floor processes, i.e. supervise them from distance and in cooperation with the local people. Mobile computing also suggests new forms of tele-operation, remote maintenance, and remote supervision of processes.

Recent advances in networking, high performance computing and resource management have introduced new possibilities for secure communication and computation intensive resource management [1], [11]. The GRID is a world-wide effort in this area, which takes advantage of improvements in the overall network bandwidth, and adds a new dimension to the distributed computing. Through the GRID environment, a large number of workstations and supercomputers can be connected in an efficient way, offering users a vast amount of computational power. However, development of communication infrastructures such as the GRID architecture and supporting GRID middle-ware (e.g. the GLOBUS toolkit), are on going world-wide efforts which will not be completed any time soon. Therefore, although GRID is promising as a foundation for networked organizations, still many of its facilities are under development, and in specific at its current state, GRID falls

short of supporting the necessary base for collaboration among autonomous business-oriented organizations. Unlike the pure scientific research, many organizations involved in applied and competitive research are keen about their autonomy and their rights to both their proprietary data and local resources, as it is also required in most applications within the VE/VO paradigm. Therefore, GRID is so far mostly being used as a partial infrastructure, on top of which, depending on the application, other functionality is developed.

Some important ***open research topics*** in virtual laboratory, e-science, and remote supervision include:

- Integration of component technologies into a coherent platform, including definition of a suitable reference architecture.
- Coordinated and dynamic resource sharing for collaborative problem solving - Direct access to hardware, software, data, etc.
- High-performance data integration for scientific collaboration - Identification of the best path for exchange of large data sets among VO members based on the on-line monitoring of distributed resources.
- Tele-supervision and tele-operation assisted by intelligent mobile agents.
- Facilities for dynamic definition of information (and services) access rights / different visibility levels for different VL community members - Encouraging joint developments while preserving rights, responsibilities, and liabilities.
- Definition of adequate representation languages for Cooperation formalization - *Cooperation* agreement / contracts, liability and risks negotiation, credit assignment (based on contributions), value and ownership of common developments, intangible entities (IPR, services).
- Social aspects and remote collaboration (lack of "silent language" of body motions and spatial positions).
- Asynchronous cooperation and delegation. Further developments in coordination approaches for diverse, autonomous, semi-cooperative, semi-reliable, heterogeneous, and evolving organizations.
- Improved mechanisms for specification of access rights (to information, knowledge, and resources) and separation of virtual spaces / experiments.
- Extended error recovery mechanisms.
- Training methodologies based on VL for manufacturing professionals.
- Integration with virtual reality and simulation environments.

8. SHOP FLOOR RE-ENGINEERING SUPPORT

The capability to rapidly change the shop-floor infrastructure is an important condition to allow participation of manufacturing enterprises in dynamic cooperative networks. Shop-floor agility implies an increasing level of re-engineering activity. So far, the processes of change (re-engineering/adaptation) have been addressed mostly at the level of business process re-engineering and information technology infrastructures. Little attention however has been devoted to the changes of the

manufacturing system itself, and yet the shop floor suffers a continuous evolution along its life cycle.

A particularly critical element in a shop-floor re-engineering process is the control system. Current control/supervision architectures are not agile because any shop-floor changes require considerable programming modifications, which imply the need for qualified programmers, usually not available in manufacturing SMEs. To worsen the situation, the changes (even small changes) might impact the global system architecture, what increases the programming effort and the potential for side-effect errors. It is therefore mandatory to develop approaches to eliminate or reduce these problems, making the process of change (re-engineering) faster and more flexible, focusing on configuration instead of codification.

A potentially promising approach is the agent-based architecture in which cooperation between agents is regulated by contracts [2]. Manufacturing components are modeled using agents, which build up a community. Each manufacturing component e.g. robots, tools, fixing devices, is associated to an agent that represents its behavior. These agents must interact in order to generate aggregated functionalities that in some cases are more complex than the simple addition of their individual capabilities. This is what happens, for instance, when several manufacturing components are working together, forming a manufacturing cell. The importance of contracts as a mechanism to create/change flexible and agile control structures (consortia) lays on the fact that the behaviors presented by agents are constrained by the contract that each agent has "signed". This calls forth that different consortium behaviors can be achieved by just changing the terms of the consortium contract, namely the skills brought to the consortium. In this way the behavior of the manufacturing system could be changed by configuration / changing of the terms of the contracts.

Progressive integration of advanced ICT tools and pervasive computing at the shop floor level is contributing to increase the level of agility but several research **challenges** remain, including:

- New integrated and comprehensive methodologies for shop-floor reengineering.
- Intelligent brokerage functionalities for manufacturing consortia formation.
- Further development of the relationships between BP requirements and contract-based shop-floor behavior.
- Methods for deriving high level control strategies out of the intended behavior.
- Definition of a kind of universal "plug and play" standard for manufacturing devices.
- Combination of re-engineering and remote supervision approaches.

9. CONCLUSIONS

ICT infrastructures are very important enabler for the effective implantation and operation of new collaborative networked organizations. In fact it is important to

notice that emerging infrastructures induce new organizational forms, but emerging organizational forms will require new support infrastructures i.e. a form of the co-evolution principle.

Recent years have noticed a fast evolution of the ICT technologies, but in spite of these developments, and due to the lack of appropriate reference models and proper characterization of the needs, a large number of challenges remain in terms of transparent and affordable plug-and-play horizontal infrastructures and support tools for the various forms of collaborative organizations and different phases of their life cycle. This situation raises the need for a larger research effort in terms of advanced ICT based architectures, tools, models, and infrastructures for collaborative networks.

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AGENT TECHNOLOGY

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A brief overview of current stat-of-the-art of the agent technology is provided. Principle concepts and architectures of agent-based solutions are presented. Basic information on available platforms, standards and ontology structures is summarized. Appropriate techniques that can be immediately used in the area of virtual enterprises are stressed. FIPA standardization efforts are highlighted.

1. INTRODUCTION

Both the complexity of the environment where we live in and operate as well as the complexity of tasks to be solved are growing rapidly. In many situations, the centralized and hierarchically organized decision-making, planning, scheduling, manufacturing and business solutions are not adequate and fail just because of high problem solving **complexity** and practical requirements for **generality** and **reconfigurability**. This fact leads to the ideas of distributed architectures and solutions, with all the time increasing degree of looseness in their mutual relationships, links and interactions.

To overcome the complexity barrier, it is quite natural to consider sets of autonomous, efficiently cooperating units being easily integrated by the "plug-and-play" approach instead of the rigid, centralized architectures. This is a clearly visible trend at all levels of manufacturing and businesses. On the real-time level where these units are tightly physically linked to the manufacturing hardware and need to operate in the machine real-time, we talk about holons and holonic solutions. Intelligent agents are helping to solve the production planning and scheduling tasks on the workshop and plant levels. The vision of intensive cooperation among enterprises being linked via communication networks has lead to the idea of virtual enterprises: "A virtual enterprise is a temporary alliance of enterprises that come together to share skills or core competencies and resources in order to better respond to business opportunities, and whose cooperation is supported by computer networks." (Camarinha-Matos & Afsarmanesh, 1999).

The philosophical background of all these highly distributed solutions is the same: efficient coordination and cooperation among autonomous intelligent goal-

oriented units can lead to a quite effective behavior of the community as a whole. Knowledge stored and exploited locally provides very interesting and useful patterns of emergent behavior – the instance of behavior that has not been implemented in the design time of the community.

2. TECHNOLOGY OVERVIEW

An agent's architecture usually consists of the **agent's body** and the **agent's wrapper** or we can say the body as a functional core is **encapsulated** by the wrapper to create an agent (Mařík et al., 2001). The wrapper accounts for the inter-agent communication and real-time reactivity. The body is an agent's component, responsible for carrying out the main own functionality of the agent. It is usually not aware of the other members of the community, their capabilities, duties etc. This is the wrapper, which is responsible for communicating with the other agents, for collecting information about the intents, goals, capabilities, load, reliability etc. of the other units in the agents' community.

From the implementation point of view, there are two types of agents: (i) **custom-tailored agents**, that are implemented in order to provide a specific service to the community (e.g. service brokering) and (ii) **integrated agents**, that encapsulate a pre-existing, "inherited" or "legacy" piece of software/hardware by the agent's wrapper into the appropriate agent structure. The integrated units use the wrapper as a standardized communication interface enabling to plug the agent into the corresponding agents' community. From the outside, such a wrapped software system cannot be distinguished from the **custom-tailored agents** as it communicates in a standard way with the others and understands the pre-defined language used for the inter-agent communication (Agent Communication Language – ACL). This *agentification processes* provide an elegant mechanism for **system integration**, a tool supporting the *technology migration* from the centralized systems towards the agent-based architectures.

2.1. Principle Concepts

There are three different concepts of agency that require a more detailed explanation:

- **mobile agents** as pieces of code traveling freely inside a certain communication network (usually inside the Internet). Such agents, being usually developed and studied in the area of computer science, are stand-alone, executable software modules, which are being sent to different host computers/servers to carry our quite specific computational tasks (usually on top of the locally stored data). They are expected to report back the results of the computation process. The mobile agents can travel across the network, can be cloned or destroyed by their own decision when fulfilling their specific task, etc.
- **multi-agent systems**, that usually create goal-oriented communities of cooperative/self-interested bodies in a certain interaction environment. They have been developed within the frame of Distributed Artificial Intelligence and they explore the AI principles for reasoning, communication and cooperation. Each agent resides on a computer platform carrying out a particular task/functionality. It communicates with the others in the extent needed for

efficient cooperation. The cooperation among the agents supported by their **social behavior** is the dominant feature of the activities of the agents in the community. The term social behavior means that the agents are able to communicate, to understand the goals, states, capabilities etc. of the others and to respect the general rules and constraints of behavior valid for each of the community member. These rules are called policies in (Bradshaw at el., 2003) or norms in (Felipe & Cordeiro, 2003). Communication (exchange of information) plays the crucial and decisive role in the agents' communities with social behavior of either cooperative or competitive nature.

- **holons** are agents dedicated to real-time manufacturing tasks (Deen et al., 2003). These are tightly physically coupled, really "hard-wired" with the manufacturing hardware (devices, machines, workshop cells) with not a very high degree of freedom in their mutual communication. The holons operate in the "hard" real-time, their patterns of behavior are strictly pre-programmed. That means that their reactions in certain situations are predictable and emergent behavior is not highly appreciated (usually not allowed). Their messages are strictly pre-programmed and pre-routed (precisely addressed in advance). The holonic manufacturing systems are designed mainly to enable a fast and efficient system reconfiguration in the case of any machine failure. One of the pioneering features of holonic systems is a complete separation of the data flow from the control instructions. The communication principles, supporting the holons' interoperability, are already standardized (in the IEC 61499 standard).

When planning a multi-agent software solution, one needs to analyze the level of centrality (communication via central component, central coordination and cooperation, centrally stored social knowledge) in the system as a whole. Central elements may make the systems easier to be developed and increase tractability and transparency of the system while making the system fragile (sensitive to the failure of the central element). Central units in the community undermine the capability of parallel information processing and local decision-making, keeping pieces of information private etc. As a result, the multi-agent system with a strong central element looses the main essence and advantage of highly distributed, locally-based flexible reactions to the changes in the environment.

2.2. Communication and Knowledge Capture

As we have already mentioned, **communication among the agents is an important enabler of their social behavior.** The agents usually explore a specific communication language (ACL) with standardized types of messages. These set of messages for a particular ACL is chosen in such a way that it represents the most typical important communication acts (speech performatives according to (Searle, 1969)) among the agents. The majority of ACLs uses limited number of message types/performatives. Each such performative contains, besides its identification, the names of the sender and receiver, the identification of the content language and the information content of the message. Additional items can be included, e.g. the reference to the appropriate knowledge ontology or the brief description of the negotiation strategy used (the structure of replies expected).

The communication among the agents is usually not just a random exchange of messages, but the message flow is managed by a set of standard **communication protocols.** These protocols range from a simple "question-reply", "request-inform" to more complex negotiation protocols like "contract-net-protocol" (CNP), subscription-based contraction or different versions of auctions (Dutch, sealed, Vickery etc.). The communication protocols and communication traffic in general can be represented graphically by means of interaction diagrams, a component in AUML – Agent-based extension to the standard UML (see Figure 1 for a FIPA REQUEST protocol example).

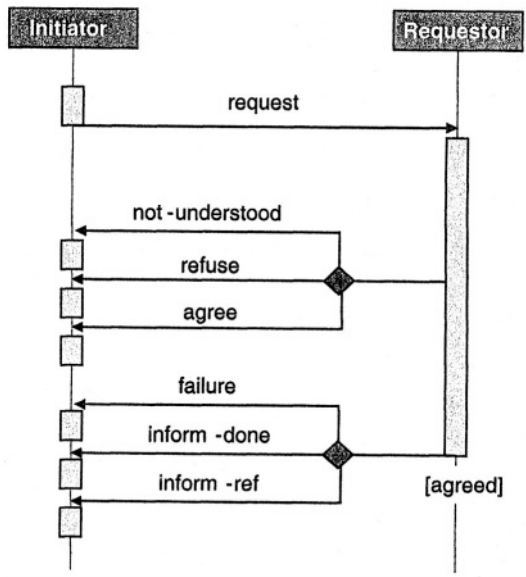

Figure 1 – FIPA REQUEST protocol in AUML interaction diagram

The more knowledge is available locally, (i.e. more knowledge is "owned" and captured by individual agents), the smaller communication traffic is needed to achieve cooperative social behavior. One of the crucial questions is how to store and use the knowledge locally. For this purpose, different **acquaintance models** are located in the wrappers of individual agents. These are used to organize, maintain and explore knowledge about the other agents (about their addresses, capabilities, load, reliability etc.). This kind of knowledge, which strongly supports collaboration activities among the agents, is called *social knowledge* (Mařík et al., 2001). These models can be used to organize both the long-term as well as temporary or semi-permanent knowledge/data concerning cooperation partners. To keep the temporary and semi-permanent knowledge fresh, several **knowledge maintenance techniques** have been developed, namely (i) *periodic knowledge revisions* – the knowledge is updated periodically by regular "question-answer" processes, (ii) *subscription-based update* – the knowledge update is pre-ordered by a specific subscription mechanism.

The strategies mentioned above enable agents to communicate as much as needed in the idle times of their operation and to significantly reduce the communication in the period of an urgent decision-making.

If at least part of the negotiation processes is based on the acquaintance model approach, a very important feature for the virtual enterprises point of view can be achieved, namely optimality of contracting from the long-term perspective (not just the optimality for one business case).

The other natural requirement is to use as short messages as possible, while keeping the information rich. For this purpose, **knowledge ontologies** as structures representing semantic knowledge about the domain knowledge are used. These hierarchical knowledge taxonomies help to explain the relationships among the concepts in the field and potential pieces of information being exchanged. They help the agents to understand and correctly interpret semantic meaning of the messages received. As a rule, each agent contains at least a part of a relevant ontology (or ontologies) in its wrapper. The main theoretical (and mainly practical) problems appear when different formalisms for ontology representation are used by different agents (see Section 5 for more details). In this case, either centralized ontology merging (Beneventano et al., 2001) or individual translation from one ontology to the other one supported by relevant distributed ontology mapping procedures (Park et al., 1998) has to be carried out.

2.3. MAS Architectures

The integration environment, which provides at least certain basic services and support for the agents' life-cycle is called an **agent platform.** Such platforms act as a medium for communication and goal-oriented collaboration among the agents. The platforms should (and many do) support flexible, dynamically evolving community of agents and enabling the agents to freely join or leave the community. Each new-coming agent should be able to register its presence and services it is able to provide with the platform. The registration/deregistration services might be either central carried out by one specialized registration agent or by several registration agents (decentralized process of registration). The platform (or registration agent) contain the *white-pages-list* and *yellow-pages-list* of agents. The white-pages-list, is a list of agents with their identification (symbolic name, host IP, communication port). The yellow-pages-list provide the agents with the list of agents and the services they provide.

Agents need to create various dynamic organizations in order to meet their specific goals. The techniques for organizing long-term **alliances** and short-term **coalitions** as well as techniques for planning of their activities (**team action planning**) have been developed recently (Pechoucek, 2002). These algorithms can help to solve certain types of tasks more efficiently and to allocate the load among the agents in an optimal way. They can be explored with advantage for automated creation and dissolving of virtual organizations as well as for an optimal load distribution among the individual bodies in a virtual organization (see Section 3 for additional details). Alliance and coalition formation techniques can be linked with methodologies and techniques for administration and maintenance of **private, semi-private and public knowledge.** This seems to be an important issue to tackle e.g. especially in virtual organizations of temporary nature where units competing in one

business project are also contracted to cooperate in the other one. It is also possible to classify and measure the necessary leakage of private/semi-private knowledge to reflect this fact in the future contracts.

The other important technology developed in the area of multi-agent systems is **processing of the meta-knowledge** by specialized, higher-level agents called **meta-agents**. This technology can be explored to monitor the activities of individual agents, to detect patterns of emergent behavior in the community and to propose specific changes in the general policies or particular items of knowledge. Machine learning principles, namely techniques of data-mining and inductive inference are usually used by the meta-agents, The meta-level knowledge potentially enables to introduce self-reflective and self-regulatory principles into the community life. When considering the applications in the virtual enterprises area, using this approach, the regulative and supportive roles of e.g. chambers of commerce, tax authorities or other legislative bodies can be successfully represented/simulated. More details on meta-agency can be found in the Section 6 of this Chapter.

2.4. Interoperability and Standardization

A lot of efforts in the multi-agent area have been dedicated to **standardization and interoperability principles.** Interoperability is one of the key conditions for applying of the "plug-and-play" philosophy. The interoperability is usually achieved through standardization. There have been several standardization initiatives recognized in the multi-agent area, but the FIPA (Foundation of Intelligent Physical Agents) consortium seems to be the most efficient and influential. It currently really dominates the scene. The FIPA consortium provides a lot of standards for organizing communication and negotiations, for creating and maintaining ontologies, etc.

The other issues intensively studied in the area of the agent-related research is the **security and information authentication.** Robust and flexible mechanisms for establishing secure channel communication links and proving the agents' identities are still in the phase of an intensive research. Standard encryption technology is not sufficient as quite new problems and security requirements appear many multi-agent systems. One of the approaches is to integrate more deeply the classical security algorithms with the advanced agent infrastructure (Novák et al., 2003). The current trend is to investigate deployment of multiple, distributed authentication authorities, reasoning under agent's inaccessibility, etc.

For better understanding of the techniques and technologies available in the field of multi-agent systems, a set of successful formalisms that can be directly applied to solve crucial tasks of knowledge handling and exploration in VO, will be presented in the next section.

3. STRUCTURING THE AGENT COMMUNITY

In principle, each agent may participate in one group of 'friendly' agents (alliance) and at the same time it may be actively involved in several groups (coalitions) of agents cooperating in fulfilling specific shared tasks (Shehory & Kraus, 1998), (Pěchouček et al., 2002). Computational and communication complexity of forming such a group (coalition) depends on the amount of pre-prepared information the

agents administer about the other "peers" and on sophistication of the agents' capability to reason about the other agents' resources, plans and intentions. The agents can allow others to reason about them and at the same time they can reason differently about the agents that belong to their different scopes of reasoning – neighborhood. Therefore, we distinguish among several types of agents' neighborhoods:

- agent's **total neighborhood**, a set of all agents that the agent is aware of, (e.g. knows about their existence and is able to communicate with them)
- agent's **social (monitoring) neighborhood** that is a set of agents, which the agent keeps specific information about (e.g. services they provide, status, load, etc.). This neighborhood consists of the set of the agents that the agent reasons about and the set the agents that reason about the respective agent.
- agent's **cooperation neighborhood** that is a set of agents jointly collaborating (or committed to collaboration) in achieving one or more shared goals.

The multi-agent community is the whole collection of agents participating in a business task. An **alliance** is a collection of agents that share information about their resources and all agree to form possible coalitions (**Pěchouček** et al., 2002). The alliance is regarded as a long-term cooperation agreement among the agents. Members of an alliance will all belong to one others' social neighborhood. An important property of an alliance is that it cannot overlap with another alliance.

Let us define a **coalition** as a set of agents, which agreed to fulfill a single, well-specified goal. Coalition members committed themselves to collaborate on the within-coalition-shared goal. A coalition, unlike an alliance, is usually regarded as a short-term agreement between collaborative agents. As we will see later, it is better for a coalition to be a subset of one alliance, but it is not a hard condition. A coalition can, in principle, consist of agents who are members of different alliances.

The coalition is coordinated by the temporary **coalition leader**, whose role can be taken by any agent, member of the coalition. It is very common that there are different coalition leaders for different tasks and goals to be solved by the community. There are different techniques how the agents may collectively decide about the coalition leader, namely plurality voting protocol, Borda voting protocol, or binary voting protocol (Sandholm 1999).

Another term to be introduced here is a **team action plan**. When planning an implementation of the collective goal, the agents must agree on how they will coordinate their activities in order to achieve the goal. The team action plan is thus a decomposition of the collective goal into a set of tasks. The tasks will be delegated within the coalition members. Apart from the responsible agent, each task shall be denoted by its due time, start time and price.

We say that the team action plan is **correct** if the selected coalition members are able to implement their allocated tasks in the given time and for the given price. The team action plan is **accepted** if the coalition members get committed to implementing their tasks following the given constraints. Similarly, we say the collective goal is **achievable,** if there exists at least on correct team action plan. The goal is said to be **planned,** if there exists a team action plan that is accepted.

4. STANDARDIZATION OF AGENTS INTEROPERABILITY

The main goal of FIPA (*Foundation for Intelligent Physical Agents*) consortium is to maximize interoperability across agent-based applications, services and equipment in an attempt to standardize communication among agents. This is done through FIPA specifications.

The **FIPA Abstract Architecture** defines a high-level organisational model for agent communication and core support for it (www.fipa.org). It is neutral with respect to any particular network protocol for message transport or any service implementation. The abstract architecture cannot be directly implemented, it should be viewed as **a basis or a specification framework for development of particular architectural specifications**. Concrete implementations cover part or all the particular specification.

The FIPA Abstract Architecture contains agent system specifications in the form of both the descriptive and the formal models. It covers three important areas, namely:

a) Agent Communication
b) Agent Management
c) Agent Message Transport

One of interesting properties of a FIPA-ACL message is its ontology that is a high-level description of a concept that organises meanings (syntax) of the respective conversation. Sometimes a dedicated agent - Ontology Agent (OA) provides the rest of the community with services such as translation of different ontologies, maintenance of public ontologies, selecting a shared ontology for communication, and others. Sending a message is usually part of certain conversation that is ruled by a conversation scenario called a **conversation or interaction protocol –** the name of the corresponding protocol is contained in a separate slot of the FIPA-ACL message. FIPA provides standards for several protocols such as simple request/query interaction, or more sophisticated negotiation protocols e.g. Contract-Net-Protocol (CNP), iterated CNP, English or Dutch Auctions, and brokering or recruiting conversation protocols.

There are many **descriptive frameworks** which describe and organise agent behaviour. Some of them represent just a rough, mainly philosophical description of different aspects of the life of a multi-agent community. They describe how the agents should behave, how they are expected to cooperate, how the organisation of the community should look like as well as which types of services and communication are recommended. These frameworks are far from becoming widely acceptable standards ensuring agents' interoperability, KQML (Finin et al., 1994), and namely FIPA-ACL represent the best developed and the most precisely defined descriptive frameworks currently available. And, moreover, the FIPA specification contains also consistent formal model of semantics for representing the content of the message (the content language) which is defined using a multi-modal logic – FIPA-SL (Semantic Language). In many respects FIPA-ACL resembles similarities with the well known language – KIF (Knowledge Interchange Format).

From a wider perspective, the FIPA standards to be applicable to virtual enterprises should consider pre-existence and co-existence of other standards. In a manufacturing industry there is STEP (Standard for the Exchange of Product Model Data) – a comprehensive ISO standard (ISO 10303) which is used for representation

and exchange of engineering product data and which specifies the EXPRESS language for product data representation in any kind of industry. Integration of these widely accepted concepts with the FIPA effort seems to be of high importance. On the level of physical interoperability there are different standards such as TCP/IP or UDP protocol, CORBA (Common Request Broker Architecture) or DCOM (Distributed Common Object Model) and others. Similarly, the higher level cooperation standards in the area of multi-agent systems such as KQML (Knowledge Query Manipulation Language), FIPA or JINI are inevitable for dynamic, flexible and reconfigurable virtual enterprises.

4.1. FIPA Compliant Platforms

While there is an extensive range of either proprietary or open-source agent development platforms (see http://www.agentlink.org) there are just a few that are fully FIPA-compliant: April Agent Platform (Fujitsu Labs of America), FIPA-OS (Emorphia), Grasshopper (IKV++), JADE (CSELT), Zeus (British Telecom). One of the first FIPA-compliant platform is FIPA-OS that has been provided as an open-source licence by Emorphia (http://www.emorphia.com, formerly Nortel Networks). FIPA-OS is a component-based toolkit enabling rapid development of FIPA compliant agents. The FIPA-OS complies with the majority of the FIPA specifications. It is fully implemented in Java and features two FIPA-OS distributions: **Standard FIPA-OS –** one distributions running under JDK1.2 and another running under JDK 1.1 and **MicroFIPA-OS** which is an extension to the JDK 1.1 version of FIPA-OS, designed primarily for execution agents on PDAs.

The main open-source competitor to FIPA-OS is JADE – Java Development Toolkit that has been implemented by Telecom Italia Labs (http://sharon.cselt.it/projects/jade/). JADE is also implemented in Java and it requires JDK 1.2. The JADE is distributed as an open source software under the terms of the LGPL (Lesser General Public License Version 2). As in the case of FIPA-OS the agent platform can be distributed across machines of different OS (if required). The configuration, which is controlled via a remote GUI, can be even changed at run-time by moving agents from one machine to another one, as and when required. JADE is backdrop for development of LEAP (Lightweight Extensible Agent Platform) that allows FIPA-compliant agents to run on PDAs and cell phones (http://leap.crm-paris.com/).

The comparison of FIPA-compliant platforms was presented in (Vrba, 2003).

5. ONTOLOGIES

Ontologies play an important role in knowledge sharing, reuse, and communication. This is particularly important for multi-agent systems, where the content of messages exchanged among agents must conform to some ontology in order to be understood.

There are two areas important for agent-based systems, in which both the ontologies and the semantics are deeply studied and intensively developed. These are namely the area of multi-agent systems (exploring information agents) and that of the Semantic Web (Hendler, 2002) in which mainly mobile agents are applied. These two large areas are different in several aspects. One of the main differences is

that ontologies in the multi-agent area tend to be standardized (FIPA plays here the key role) and unchanging in order to get at least partially guaranteed behavior. On the other hand, in the Semantic Web, nothing is guaranteed – ontologies can be changing and inconsistent, and mobile agents that work with them are expected to be able to handle them, though they may not get always the required results.

Despite the differences, these areas can mutually inspire each other.

An ontology is usually defined as an explicit specification of conceptualization. In the sense presented in (Gruber 1993) explicit specification of conceptualization means that an ontology is a description of the concepts and relationships that can exist for an agent or a community of agents. Only what can be represented using an ontology can be represented in agent's knowledge bases. More importantly, only that can be described in messages exchanged between agents.

The ontology defines how to model the state of affairs in a domain together with restrictions what is possible and what is impossible. Ontologies are developed and used because they enable among others:

- **to share knowledge –** by sharing understanding of the structure of information shared among software agents and people
- **to reuse knowledge –** an ontology can be reused for other systems operating on a similar domain
- **to make assumptions about a domain explicit –** e.g. for easier communication

The semantic interoperability (a possibility to understand shared data, information, and knowledge) is one of the main reasons why ontologies are being used.

It was supposed that it should be possible to conceptualize a domain and create a common shared ontology so that any system working on that domain could use that ontology for sharing knowledge. However, it seems that ontologies for one domain designed by two ontology engineers are always different, even if they use similar modeling methods and approaches. When two organizations create their ontology for a shared domain, ontologies will never be the same. Rational reasons for the fact that ontology that would be optimal for everyone is impossible are given in (OLeary, 2000). That's why the current research partly shifts to developing standards for achieving interoperability between existing ontologies rather than developing standardized monolithic ontologies (Handler, 2002). However, developing ontologies certainly still remains as a research issue.

Ontologies should be well designed and also well defined. By a good design we mean that they should adequately capture the modeled domain, be understandable by a human user and provide good support for machine processing. By a good definition we mean not only the syntax, but also the semantics. The formal semantics is important if we want to have automated reasoning over ontologies. Such reasoning enables to support ontology design (such as consistency checking or supporting more authors authoring one ontology), integrating and sharing ontologies automatically, determining and establishing relationships between ontologies etc. One of the important issues is to find the **balance between ontology expressivity and reasoning support**. The time complexity of reasoning algorithms can be considerably increased when adding means of expressivity, or the reasoning possibility can become intractable or be lost completely. Without reasoning support, no automatic interoperability can be achieved in the general case. E.g. KIF

(Knowledge Interchange Format (Genesereth et. al, 1994)) is very general, but has no reasoning support. On the other hand, OIL (Ontology Inference Layer (Fensel et. al, 2000)) provides fast reasoning support, but is too restrictive in some applications.

6. META-AGENTS

As we mentioned previously, the agents, members of the multi-agent system are required to act as autonomously and independently as possible. The amount of central agents and central management components is required to be as little as possible. However, from the practical point of view, we very often need some special agents that provide the other agents with special functionality. Let us call these agents meta-agents.

Many researchers approached the problem of meta-agency from different points of view. Very often the agents, that reason or maintain knowledge about the community of object agents, are linked to the agents' interaction platform (e.g. **facilitators**, which play the role of communication interfaces among collaborating agents (McGuire et al.,1993) or DF and AMS components in FIPA that administer the white-page and yellow-page list of agents). However, meta-reasoning can be implemented also by loosely coupled agents such as **brokers**, which are responsible for finding the best possible addressee of the transmitted message (Shen et al., 2001), **matchmakers** which also suggest cooperation patterns that may be equally used in the future (Decker at al., 1997), or **mediators**, which besides facilitating, brokering and matchmaking coordinate the agents by suggesting and promoting new cooperation patterns among them (Shen et al., 2001). If these agents are tightly connected to the implementation platform, they have been classified as **middle agents** (Sycara, 2001).

Unlike the middle agents, the meta-agent is a loosely coupled agent that does not facilitate any functionality that is inevitable for operation of the community of agents. As any other reflective component of a computational system, the meta-agent is connected with the agents in the community via causal connections (introspective integrity and introspective force (Maes, 1987). This is not the case of the specialized agents (facilitators, brokers, etc.) listed in the previous paragraph as they take an active (irreplaceable) role in the agent's operation. The meta-agent observes the behavior of the community and tries to draw some assumptions about the agents' behavior. This type of meta-agent can use certain type of domain-relevant knowledge to help the other agents to make optimal decisions and therefore improve the performance of the multi-agent system as a whole. By introducing the concept of the meta-agent, one may get an overall view of the community's functionality. The use of multiple meta-agents avoids making the meta-reasoning process too fragile by relying on a single independent meta-agent, which can become a bottleneck of the process of meta-reasoning.

According to impact that has the meta-agent on the community of agents we distinguish between:

- **passive meta-agent**: In this case the meta-agent has no impact on the other agents, it does not intervene in their operation. This type of meta-reasoning is used primarily for purposes of visualization, explanation and simulation.

- **active meta-agent**: In this case, the meta-agent reflects back the results of the meta-reasoning process and makes an attempt to influence the agents in the community by revising their knowledge, commitments and intentions. This instance of meta-reasoning is used for constructing adaptive and reflective multi-agent systems.

The central point of the meta-agent's operation is an appropriate syntactic model (let us consider this model to have a form of a set of true formulas) of the community. This model has to be expressed in an appropriate language of adequate granularity. For any reasonable manipulation with the model, we need to specify the relevant semantic properties of the agents' community it supposed to model. This is what we will refer to as the **background knowledge**. In the simplest case this is a theory in first order logic.

Analogically to the model of social knowledge presented earlier, the **meta-agent's monitoring neighborhood** is a collection of agents that are subject of meta-agent's meta-reasoning processes. The meta-reasoning process in a multi-agent system is built upon three mutually interconnected computational processes:

- monitoring: process that makes sure that the meta-agent knows the most it can get from monitoring the community of agents. This process builds basics of the model of the community and implements the *introspective integrity* (in the sense of (Maes, 1987)). The monitoring process preserves truthfulness of the model, while it cannot usually assure perfectness of the model.

- reasoning: this process manipulates the model of the community so that other true facts (other than monitored) may be deduced. Within the reasoning phase the meta-agent tries to extend the model and to maintain its truthfulness.

- community revision: a mechanism for influencing operation of the object agents' community. This process is inevitable if the meta-agent reasoning phase results in such a goal hypothesis, that is not true in the community, while it ought to be (such as efficiency improvements or agents' awareness of the intruder operating in the system). In this phase the meta-agent may also affect the operation of the community in order to improve the meta-reasoning process.

In the reasoning phase, that is the key of the meta-reasoning process, we make a great use of various available artificial intelligence techniques. Researchers have experimented with and implemented meta-reasoning by means of machine learning, theorem proving, Bayesian networks, truth maintenance, case-based reasoning, etc.

7. CONCLUDING REMARKS AND RECOMMENDATIONS

This chapter has presented just a brief overview and description of the results in the multi-agent area as a **motivation for the area of virtual enterprises**. Only the most important aspects were picked up. We believe, there is no obstacle to transfer the successful multi-agent technologies into the area of virtual enterprises and organizations and to leverage the results. This text should help to bridge the gap between the scientists in the multi-agent area and those developing virtual enterprise concepts. The extension from production planning and scheduling or coalition formation solutions towards virtual enterprises would cause no serious difficulties in the case the philosophy, terminology, principles of interoperability etc. will be jointly accepted in both the fields.

FIPA standards seem to be a good starting point for standardization, despite the fact there is a lot of work to be carried out to develop specific set of messages and ontologies for the virtual enterprise area which would become widely acceptable.

Despite the significant progress achieved in the field of multi-agent systems, the available architectures, platforms and solutions are still not mature enough to be directly re-used in the field of the Virtual Enterprises.

Agent-based systems need further intensive and deeper research to provide all the necessary properties needed for Virtual Enterprises. Along with (Luck at all, 2003) we feel it is necessary namely:

- to make progress in development of communication and negotiation standards and policies,
- to develop widely acceptable agent platforms supporting the virtual enterprises
- to develop computational models of norms, social structures and libraries of algorithms for their deployment
- to develop matrics to evaluate the efficiency of the multi-agents systems (e.g. evaluating the overall profit of the VE solution),
- to handle the different types of knowledge (private, semi-private, uncertain, vague, etc.)
- to develop efficient knowledge ontologies,
- to develop trust and reputation mechanisms, etc.

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ON EMERGING TECHNOLOGIES FOR VO

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This chapter briefly describes some of the recent technologies that are likely to have a significant contribution to support virtual organizations. A fast proliferation of Internet-related technologies has been observed in the last years, but most of them have a very short life cycle. Therefore only a subset is included in order to give a brief overview of current trends but also to identify the need to pursue with longer-term developments less dependent on particular technologies.

1. INTRODUCTION

Last years have been quite fertile in terms of a fast proliferation of new ICT tools and standards aimed at facilitating different aspects of collaborative networks. Giving a comprehensive account of all available "contenders" and emerging systems is outside the scope of this book and would not be of interest as most of these systems serve only a limited part of the required functionality for the VOs and typically have a very short life cycle.

Nevertheless, among the large proliferation of new technologies and standards some of them appear to be the main contenders supporting the ICT environments for collaborative networks. The following sub-sections, and mainly as an illustration, show a few examples of the variety of emerging technologies that are likely to be applied and have some impact on the development of support software for virtual organizations and other collaborative networks, including: ebXML, RosettaNet, GRID, web services, J2EE, .NET, and VPN. Please note that a major technology, that is increasingly gaining importance in this area, is the multi-agent systems, which was the subject of a previous chapter in the book.

2. ebXML AND ROSETTANET

Information exchange has always been a key issue in inter-enterprise collaboration. Earlier VO projects heavily investigated the suitability of "traditional" standards

such as EDIFACT and STEP. However, as it was found out, in addition to the complexity of their implementation, problems arise when the collaborative transactions extend beyond the scope of these two standards.

The emergence and rapid proliferation of XML opened some new opportunities for inter-enterprise / inter-application document exchange. However, the simple naïve belief that XML was "the solution" to all data exchange problems was soon broken by the proliferation of a wide range of XML document variants. Furthermore, understanding the syntax or structure does not touch the difficult data semantic issues. Therefore, more focused initiatives emerged such as the ebXML and RosettaNet, relying on XML as one of the base technologies, but targeting the business domains and the business-to-business interactions.

The business extensible Markup Language (ebXML) is a joint initiative of UN/CEFACT[1] and OASIS[2] aiming at defining a set of standard specifications that form a framework to support inter-enterprise business collaboration. This framework is based on mutually accepted trading partner agreements, as well as a technical infrastructure which enables businesses to find each other and provides for the reliable and secure exchange of standardized XML-based business messages, between collaborating business partners. In order to achieve this, ebXML leverages most of the critical, but divergent, XML initiatives that were already underway, to ensure interoperability and to accelerate the design of the framework. It also leverages the experience of the traditional EDI sector and accommodates both EDI and XML vocabularies. Unlike EDIFACT that was quite hard to implement by small companies, ebXML is intended to allow easier implementations.

ebXML supports business processes and business partner agreements expressed in XML, as well as business service interface to implement these agreements. A transport and delivery layer supports the information exchange, and a registry and repository component acts as a container for process definitions, vocabularies, and partner profiles, providing the base for partner discovery. Business processes are executed through a workflow-like engine.

The ebXML framework also considers mechanisms to allow the specification of the quality of service, timeouts, confirmations, multi-language support, authentication, authorization, privacy, integrity, and non-repudiation [7], [8].

RosettaNet is an initiative of a non-profit consortium of more than 400 companies aiming at developing and deploying standard interfaces between trading partners, namely for high-technology industries. At a first glance there is some overlap with ebXML, although RosettaNet is more focused on the definition of business processes and their choreography, i.e. the sequence and dependencies of interactions between multiple roles to implement a business process, that itself may be composed of multiple services. In particular, the Partner Interface Process (PIP) is a model in which activities, decisions, and partner roles and interactions are defined in order to fulfill a business transaction between two partners. The business choreography is essentially agreed in advance, what is adequate for industries with largely standardized business processes. RosettaNet considers facilities for confirmation,

[1] United Nations Center for Trade Facilitation and Electronic Business

[2] Organization for the Advancement of Structured Information Standards

non-repudiation, use of multiple languages, SSL (Secure Sockets Layer) authentication, digital signature, and data encoding [7], [9].

Both ebXML and RosttaNet initiatives seem to be developing in the same direction although ebXML appears to be more general and RosettaNet more focused on a particular type of industry. A comparison between the two can be found in [7]. Nevertheless it shall be noted that both initiatives are focused on B2B transactions, lacking more advanced functionalities to support multi-party collaboration processes as required in advanced collaborative networks.

3. GRID COMPUTING

Grid computing denotes an infrastructure for distributed computing. As an example, the Globus Toolkit allows users to make use of distributed high-performance resources for the execution of their jobs. It allows users to discover a resource based on requirements specification, allocate a resource for a certain time, submit a job to a resource, and retrieve the results back from a resource. A job can be an executable, or a command for a remote host. Resources can be data (usually as files), computing facilities (usually supercomputers or clusters), networking facilities, or storage facilities.

Grid is an open-source system. It is possible to define new services (e.g. generating new toolkit components for parallel computation), or to attach new resources (e.g. making a Linux cluster available to grid community by installing the Globus software and creating the necessary user maps).

This new technology constitutes 3 main innovative contributions:

- Distributed resource management
- Single sign-on for users
- Grid security infrastructure.

Looking back at the horizontal infrastructure classification for VE/VO, this technology can be considered for all categories except for the coordination tasks. Bellow a description of how different VE/VO requirements can be supported by Grid is provided:

- General information and knowledge sharing - Data management in Grid is mainly addressing large data sets stored as files. For the purpose of file management, high-performance archives, replica management systems, and meta-data directories for the data stored by replica managers are being developed. Also GridFTP protocol is being defined for data exchange. Also OGSA-DAI is developing further features to support data / information sharing.
- Safety / security - Grid Security Infrastructure (GSI) is an infrastructure based on public-key / private key and certificates based infrastructure. Users create proxies that will authenticate their usage of resources on their behalf. The main idea is the *single sign-on.* Every resource will than map the Grid user to a local user and defines the permissions on this local user (usually at the level of the OS permissions). Each resource has certain trusted certification authorities. If the certificate of the user (encoded in his proxy) is

signed by one of these authorities, and if the user has a local mapping for the resource, then he is allowed to access the resource.

- Interoperability and legacy systems integration – The Globus Toolkit is implemented for many UNIX and Linux platforms. Also several wrappers for the Toolkit client have been developed for Java, Perl, etc. Using these wrappers, users can submit jobs to remote systems and systems can accept jobs from remote clients, where the jobs must be suitable for the target system (e.g. in case of running a program on a remote Linux machine, the job must be compiled for that Linux OS). Some new developments for GRID, in specific OGSA, is moving towards the service-based approach, where all functionality provided by resources, through the GRID, will be represented as (Web) services.
- Collaborative environments – It is handled only at the level of contracts among several nodes on the subject of sharing their resources but also surprisingly called "Virtual Organizations" in Grid! However, Grid's virtual organization shares only the above limited similarity to the usual meaning of the VO paradigm.

In terms of functionality support, the Grid technology can also fit some categories of the required VE/VO creation and operation functionality.

- Partners search and selection / e-procurement - Currently there are LDAP based catalogues for storing and querying information about available resources and their current status. This is used for Grid job scheduling. The new version of tools that also introduces catalogues for services, and keeps information about the operations of these services.
- Contract / agreement negotiation - When a new node joins the Grid, it defines which Grid users can use its resources, by defining mappings from Grid user accounts to the local user accounts.
- Distributed BP planning and scheduling - There is no BP defined in Grid. Planning is used in Grid to only specify the requirements for execution of the jobs. Scheduling is also only at the level of jobs, finding a suitable resource that matches with the requirements specified by the user. With the new plans for GRID and Globus developments, there are some thoughts on how to aggregate several services with each other, but the plans for coordinating their execution is not yet clear.
- Dynamic performance assessment - It is at the level of a remote job. When a job is submitted, performance of that job and the used resources are monitored, mainly for resource management purposes.

4. WEB SERVICES

4.1 W3C Web Services Architecture Working Group

The paradigm of e-Services is being developed and/or adopted by a growing number of recent projects. However, most of the developments are focused on e-Commerce or B2B, i.e. mainly under a "transaction-oriented" perspective (see Fig. 1).

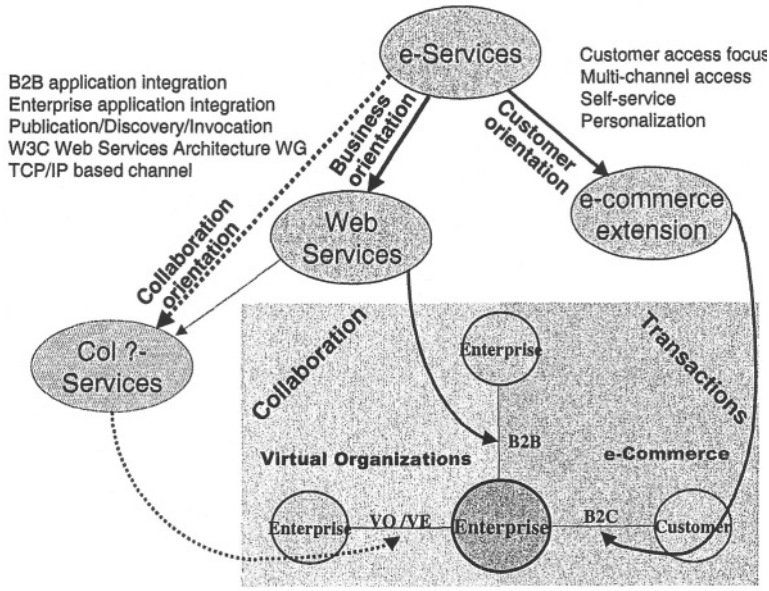

Figure 1 – e-Services

In terms of its adoption in VE/VO it is necessary to put the emphasis on "collaboration" rather than on "transaction".

For the case of web services, there are relevant ongoing efforts in terms of standardization, mainly carried out by the W3C Web Services Architecture Group. This organization defines a web service as

> "*a software application identified by a URI, whose interfaces and bindings are capable of being defined, described, and discovered as XML artefacts. A web service supports direct interactions via Internet-based protocols*".

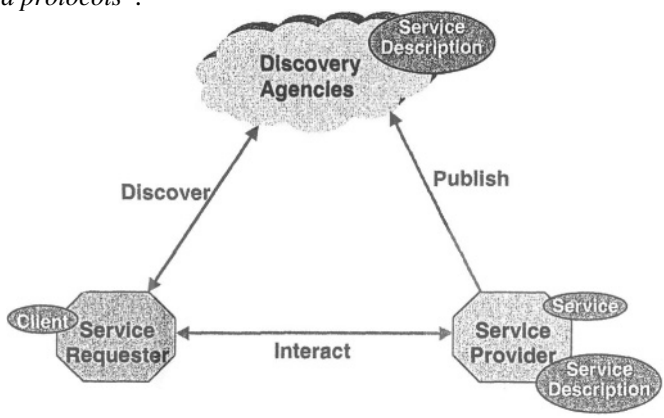

Figure 2 – Web services [www.w3.org/TR/2002/WD-wsa-xxx]

Web Services are self-contained, self-describing, modular applications that can be published, located, and invoked across the Web. Web Services perform functions that range from simple requests to complicated business processes. Once a Web service is deployed, other applications (and other Web Services) can discover and invoke the deployed service (Fig. 2).

In this context a number of standards are being proposed, for instance, the WSDL, UDDI, SOAP, etc. (Fig. 3). The security aspects are being standardized by OASIS. QoS (Quality of Service) infrastructures are still at a very early stage of development.

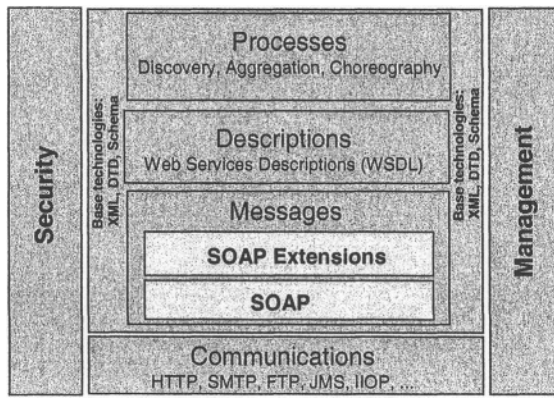

Figure 3 – Web services stack [www.w3.org/TR/2003/WD-ws-arch-20030514/]

Although the basic concepts of remote service invocation are technically manageable even in inter-enterprise scenarios and already proven to work in many cases, there are still several problems requiring further attention. For instance:

- What happens if a Web service implementation is not available? For example, if the service provider has revoked the Web service implementation or the system is down for some time, the requesting client may be unable to proceed. There is no other way to discover unavailability before service invocation.
- What happens if the service provider changes the implementation in a way that it is no longer compatible with the published interface? In that case, the service requester must also adapt to the new interface. However, if the transition goes unannounced and not noticed, the service requester will receive an error.
- How do service requester and service provider understand each other? – the challenging semantic issue. WSDL and SOAP provide for technical syntactic interoperability but not for semantic interoperability. There is no guarantee that service requester and service provider have a common understanding of the message content. Definition and integration of common ontologies is therefore a must.

In order to handle the semantic aspects EDI has tried to provide a fixed, predictable message format for certain kinds of business transactions. With ebXML, it is

possible to have the messaging features of EDI, plus a larger framework of functions combining business process models, registries, company profiles, trading partner agreements, and semantic interoperability. Web services, on the other hand, offer some of the same business functions as ebXML - messaging, service descriptions, registries - but in a more component-oriented form. In general terms ebXML is about loosely coupled document-centric business collaboration while with Web services, the API-centric (or service interface) view dominates (rather than the document-centric view as with ebXML) [5].

4.2 Some components of web service technology

UDDI. The Universal Description Discovery Integration (UDDI) creates a platform-independent, open framework for describing services, discovering businesses, and integrating business services using the Internet, as well as an operational registry that is available today.

The UDDI business registry includes three kinds of information: *white pages, yellow pages* and *green pages.* The *white pages* component is a listing of business entities and ability to search companies by their name. The *yellow pages* categorize business entities into their business categories and other sorts of applicable categories. The *green pages* add the ability to understand a service definition and its access requirements.

Providing all these information enables an online application such as a web service an automated way to find and access other services as well as the distribution of the service itself. Application server providers such as IBM have integrated UDDI in their solutions or are working on the integration. Using such servers enables companies and organizations to publish and retrieve web services and enables collaborative working inside a company, between companies, or both.

WSDL. The Web Services Description Language (WSDL) is an XML format for describing web services and how to access them. It specifies the location of the service and the operations (or methods) the service exposes. Once a service provider has developed a Web service, he can publish its description and a link to it in a UDDI repository so that potential users can find it. When someone thinks they want to use the service, they request the WSDL file in order to find out the location of the service, the function calls and how to access them. Then, they use this information in the WSDL file to form a SOAP (Simple Object Access Protocol) request to the service provider's computer.

SOAP. Simple Object Access Protocol (SOAP) is an XML based protocol to let applications exchange information over HTTP. In the past applications used to communicate using Remote Procedure Calls (RPC) between objects like DCOM and CORBA, but HTTP was not designed for this. RPC represents a compatibility and security problem; firewalls and proxy servers normally block this kind of traffic. A better way to communicate between applications is over HTTP, because HTTP is supported by all Internet browsers and servers. SOAP was created to accomplish this. SOAP provides a way to communicate between applications running on different operating systems, with different technologies and programming languages.

WSIL. The Web Service Inspection Language provides an XML format for assisting the inspection of a site for available services and a set of rules for how inspection related information should be made available for consumption. A WS-Inspection document provides means for aggregating references to pre-existing service description documents which have been authored in any number of formats. The two major design goals of the WS-Inspection specification are simplicity and extensibility. The fact that a WS-Inspection document may point to a variety of service description document formats allows the consumer of the document to pick and choose from the available descriptions and to access only those that it is able to understand. Within a WS-Inspection document, a single service can have more than one reference to a service description. For example, a single Web service might be described using both a WSDL file and as a UDDI registry. References to these two service descriptions should be put into a WS-Inspection document. If multiple references are available, it is beneficial to put all of them in the WS-Inspection document so that the document consumer can select the type of service description that they are capable of understanding and wish to use.

WSIL addresses directly one of the main problems of collaborative networks, i.e. finding a required service. Different, autonomous business domains must be jointly involved to provide upper level services. The finding of a partner providing the right service was reduced to the usage of a centralized registry, as a UDDI registry, until now. The WS-Inspection-Technology opens new possibilities to the service provider to advertise services as well as to the service requester to find the desired service. The very important thing is, WSIL does not exclude or restrict the already existing solutions, but extends them. WSIL is a specification proposed by IBM and Microsoft. Although WSIL is still a proprietary specification, both IBM and Microsoft have announced their intentions of submitting the WSIL specification to standardization bodies, probably the World Wide Web Consortium (W3C).

SAML. The Security Assertion Markup Language (SAML) is being developed by the Organization for the Advancement of Structured Information Standards (OASIS) as a standard for exchanging authentication and authorization information between domains. It is an XML application and is meant to be vendor neutral.

SAML includes three types of assertions: *authentication assertions, attribute assertions* and *authorization decision assertions. Authentication assertions* validate the user's identity, enabling the user to go to another website or domain without repeated authentication. *Attribute assertions* provide information about the user, such as spending limits. *Authorization decisions assertions* confirm a user's authorization to perform some action, such as buying some items.

SAML is designed to offer single sign-on for both automatic and manual interactions between systems. It will let users log into another domain and define all of their permissions as well as manage automated B2B exchanges between two parties. SAML is related to Web services, since both technologies are designed to simplify interoperability and are based on the same standards. Like Web Services, SAML uses SOAP as its communication protocol. Web Services Security provides a framework for different assertions and certificates, such as SAML, to operate and exchange data in a standards-based manner.

Security is a key challenge for collaborative online work among businesses that require a high level of trustworthiness. Authentication and authorization are not only basic elements to provide security, but in fact the requirements to even launch an e-business web service. Therefore, SAML represents not only a standard for specific scenarios or contexts, but also provides basic support for collaborations. Additionally, SAML aims to simplify interoperability between systems or networks, which is an important requirement for automated services across different domains within a complex community of several parties.

BPEL4WS, WS-Coordination and WS-Transaction. The Business Process Execution Language for Web Services (BPEL4WS) specification defines a notation for specifying business process behavior based on Web Services. Together with two further complimentary specifications, the WS-Coordination and WS-Transaction it presents efforts to standardize business process workflow and execution to increase transaction reliability and synchronization.

BPEL4WS allows specifying business processes and how they relate to Web services. This includes specifying how a business process makes use of Web services to achieve its goal, as well as specifying Web services that are provided by a business process. Complex processes can be created by wiring together different activities that can for example, perform Web services invocations, manipulate data, throw faults, or terminate a process. These activities may be nested within structured activities that define how they may be executed, such as in a sequence, in parallel, or execute depending on certain conditions. In BPEL4WS business processes are addressed in two ways: executable business processes that model the actual behavior of a participant in a business interaction, and business process descriptions that specify the mutually visible message exchange behavior without revealing the participants' internal behavior.

The WS-Coordination and WS-Transaction specifications complement BPEL4WS by providing a Web Services-based approach for improving the dependability of automated, long running business transactions, in an extensible and interoperable way. WS-Coordination describes an extensible framework for providing protocols that coordinate the actions of distributed applications. The framework enables existing transaction processing, workflow, and other systems for coordination to hide their proprietary protocols and to operate in a heterogeneous environment. The WS-Transaction specification describes coordination types that are used with the extensible coordination framework described in the WS-Coordination specification.

The specifications described above address directly the major problems of collaborative networks where different heterogeneous and autonomous business domains need to be jointly involved in the provision of common business processes. The specifications will help organizations to coordinate business processes and transactions within the organisation and with partners and customers across heterogeneous systems. These are the building blocks that are used in conjunction with other Web services-related specifications and standards to accommodate operation of distributed Web services. These specifications are not yet standardized. Furthermore, there are some other specifications, regarding the same field of the Web services, but supporting distributed business processes. The adoption of one of the considered specifications as standards e.g. OASIS, W3C, and WS-I, by

standardisation bodies, as well as the maturation of the enabling tools and their implementations, will definitely bring a significant value to enabling collaboration between different domains.

4.3 J2EE and .NET

Although Web services seem to be offering a promising technological approach, the selection of tools to implement this technology remains a major challenge. Two of the contenders offering architectures that promise to build and orchestrate distributed applications are Microsoft's .NET and Sun Microsystem's J2EE approaches [1].

Both approaches – J2EE and .NET – share a common conceptual framework architecture promoting interoperability and collaboration among distinct enterprises to achieve common goals.

The framework architecture follows the software development methodology that divides Interface, Control and Entity means – the ICE architecture. Therefore, both J2EE and .NET are three-tier architectures, composed of:

- Interface tier – the tier responsible to work with clients, Web browser or any other. It accepts requests via HTTP and returns results as HTML.
- Control tier – the control tier is where business logic is implemented. Because this tier is placed between the Interface tier and the Entity tier, it is usually called the *middle tier.*
- Entity tier – the Entity tier, or *database tier,* is where actual data is stored.

Regarding communication between tiers, both approaches have their own technology but they do quite the same. Between the Interface and the Control, J2EE uses RMI/IIOP while .NET uses DCOM or SOAP. Between control and entity tiers the J2EE uses JDBC while .NET uses ADO.NET.

Furthermore, because both frameworks intend to support large scale runtime environments, two other technologies are used in the middle tier. In J2EE Enterprise JavaBeans is used and in .NET COM+is used.

In terms of supported functionalities it is difficult to evaluate them since these two frameworks lie in a lower abstraction level. Furthermore, they are both promoting technologies rather than implementations of solutions.

Some issues that can be taken into account when deciding on which approach to adopt include:

- Existing environment on the client side (where Microsoft dominates most of the market)
- Application platforms, which are likely to be heterogeneous in a VO environment (here, at present SUN's J2EE has a greater appeal due to its portability)
- Costs of migration, philosophical issues (the question of Microsoft's monopolistic practices), etc.

The important issue of practical guidelines for technology selection shall be further developed given its importance to SMEs.

5. VIRTUAL PRIVATE NETWORKS

Safety and security has always been a matter of major concern in ICT infrastructures for VOs.

Initial projects needed to each develop basic security mechanisms sometimes through integration of different component algorithms, a situation that is nowadays improving. By integrating a number of concepts and algorithms, previously developed in various areas, the Virtual Private Network (VPN) technology is becoming available as a possible solution. A VPN is a combination of software and hardware which allows mobile users, teleworkers and remote nodes to use an insecure public network (such as Internet) to establish a secure, private connection to other nodes on the network (e.g. an intranet or extranet). In other words, virtual private networks are secure virtual networks, layered on top of existing network infrastructures. For Internet protocol (IP) based networks, VPNs are created using encrypted IP tunnels through the Internet. These tunnels form a new IP based network that appears like a local area network.

Promising advantages provided by VPN, include the following [4]:

- Confidentiality. VPNs can use various security protocols, but at present most of the implementations use IPsec[3], developed in the framework of IETF[4]. IPsec allows the use of several cryptographic algorithms and the selection of their key lengths.
- Integrity. IPsec also provides some integrity features, since it uses hybrid cryptography and digital certificates.
- Authentication. IPsec defines the requirements to be met by the authentication methods used. These mechanisms are based on the ISAKMP[5] or IKE[6] authentication and key exchange protocols, which are the *de facto* standard for VPNs.
- Protection against Replay attacks. IPsec provides mechanisms which detect repeated frames and ignore them, turning these attacks ineffective.
- Application independence. IPsec works on layer 4 of the OSI model, and it also sits on top of the TCP/IP and below the application level.
- IP address routing. VPNs were initially conceived to be able to securely transmit information between branch offices of a company. Therefore, IPsec works in a way that allows encapsulation of the IP address of a private LAN inside another packet with the IP of a public network (usually Internet). In this way the packets can be routed through the insecure channel.
- Compliance with standards. VPNs have adopted almost all of emerging standards being developed for the new IPv6 Internet protocol. This compliance with standards guarantees not only continuity, but also interoperability between manufacturers. Indeed, IPsec is part of the IPv6.
- Hardware and software implementations. Since the VPN specification is open, as are its standards, there are multiple software and hardware

[3] IPSec – IP Security protocol

[4] IETF – Internet Engineering Task Force

[5] ISAKMP – Internet Security Association and Key Management Protocol

[6] IKE – Internet Key Exchange

implementations for different market segments. These range at present from free software solutions (Linux, BSD...) to solutions integrated in hardware (routers/firewalls from different suppliers), including software solutions for mobile devices (PDAs, phones, etc.).

- Support hardware (cryptographic accelerators). There are cards with cryptographic algorithm support co-processors that support various operating systems.

Nevertheless, and due to being an emerging (not mature) technology, VPN also suffers from some limitations. A major drawback is the speed. Additionally, current VPN technologies suffer from problematic installation and management, requiring expertise and long time to stabilize. Most VPN solutions require a central server to route the packets between users. This topology can create a bottleneck when the number of concurrent users grows.

In spite of current limitations, given the importance of the area and the current ongoing efforts, it is likely that general secure application independent frameworks, will become common practice, facilitating the development of secure VO support infrastructures.

It is however, important to notice that a global security architecture for advanced collaborative networked organizations needs to combine other levels of security and privacy, such as, for instance:

- Biometric systems for user authentication.
- Specification and control of access rights to distributed resources.
- Fine granularity of specification and enforcement of information visibility levels, what can be achieved with federated information management approaches.
- Etc.

6. MOBILE AND PERVASIVE COMPUTING

6.1 Mobile Computing and Communications[7]

Mobile technologies offer a wide range of value-added services to the members of collaborative networked organizations, including support for:

- Coordination and collaboration
- Information access, retrieval, and exchange, and
- Content access and delivery.

Those services will be implemented by future workspaces and supported by adequate back-office processes. The basis for such services will be mobile and wireless communication technologies, which are currently subject of research, development, and standardization.

[7] This section is based on the paper 'Service Architectures for the Wireless World' by R. Popescu-Zeletin, S. Arbanowski, I. Fikouras, G. Gasbaronne. M- Gebler, S. Henning, H. van Kranenburg, H. Portschy, E. Postmann, K. Raatikainen, Computer Communications 26 (2003), 19-25

Since September 2001, the Wireless Word Research Forum (WWRF) has worked in the area of service architectures for future wireless systems. Its Working Group 2 is looking for communication systems, which are able to model the preferences of each individual mobile user, and which can adapt to different situations in time.

Those architectures are intended to at least support ambient-awareness, personalization, and adaptability. The reference model shown in Fig. 4 for mobile and wireless communications illustrates the findings of the working group described in a series of white papers, which represent a common understanding between research and industry.

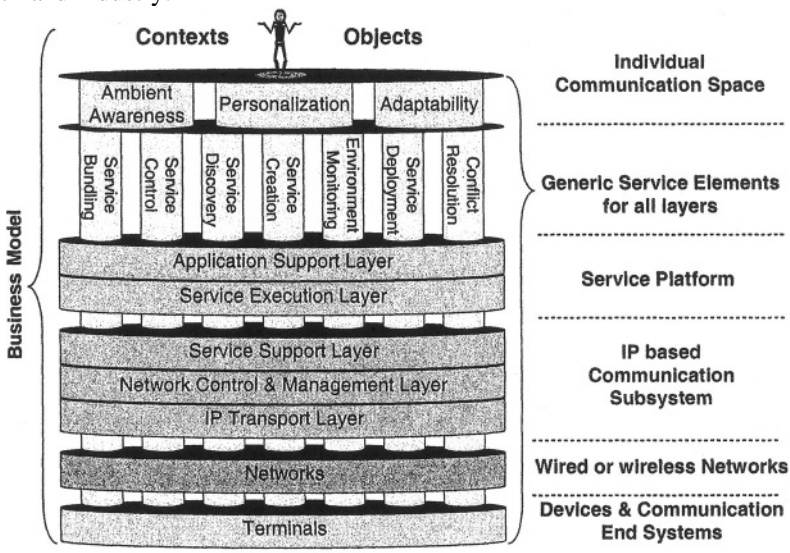

Figure 4 - Reference Model for Mobile and Wireless Communications

The service platform suggested in this model is responsible for configuring the communication system required according to the individual communication spaces, contexts, preferences, and the ambient information. The IP-based communication subsystem is responsible for the linkage between different objects in the communication spaces. IP communication is the common denominator for the harmonization of heterogeneous network infrastructures. The wired or wireless network layer implements the physical connections between the different end points involved, so that a connection in the IP-based communication subsystem may use different physical connections in the underlying network. The devices and communication end system layer represents the physical end-system infrastructure.

On top of the service platform, a set of Generic Service Elements implement the concept of a toolbox from which complex services can be assembled and executed dynamically. Three key complex services are:

Personalization. Personalization is a key factor for the success of mobile services. It includes the parameter selection, configuration, and arrangements representing the user's preferences and characteristics, which make the individualized communication space richer and the usage easier. In longer term, personalized

services are likely to provide experiences and emotions in addition to data and content.

Ambient Awareness. Ambient awareness deals with sensing and exchanging of spatial information, e.g. location, orientation, speed, and acceleration, physiological information, i.e. life conditions like blood pressure, respiration rate, and tone of voice, as well as environmental information, including temperature, light and noise level. The ambient awareness services intend to acquire and utilize such information in order to adapt the communication space to the situational and environmental context of the individual user.

Adaptability. The WWRF has identified a set of functions necessary to make a communication space adaptable to a changing context. These functions include environment monitoring, event notification, distributed application framework, perception service, modeling service, mobile distributed information base, ontology service, and semantic matching engine. Environment monitoring and event notification enable the system to detect and report context changes. The distributed application framework includes service discovery and auto-configuration. The modeling service comprises a model builder, model combiner, model evaluator, and a perception service used to handle the various models necessary to support adaptive services, including models of user preferences and behaviour, quality of service, environment, etc. The mobile distributed information base is to provide a distributed, world-wide file system or database, containing perceptions, user parameters, device capabilities, as well as users' own data together with intelligent synchronization, roled-based views and transactional operations with user-defined semantics. The ontology service is to provide a terminology as well as a set of well-defined concepts that are able to describe the communication parameters, user behaviour and situation, in the distributed world of interest in an unambiguous way. The semantic matching engine provides a set of matching rules and a common, semantic-based representation of the user preferences, device capabilities, and application requirements.

Business Models. We observe two major trends in the development and introduction of business models for the provision of value-added communication and computing services:

First, there is an increasing influence of business considerations on the functional communications architecture and it is expected that the future communication system will be made up of multiple technologies configured around specific user requirements identified in the market.

Due to increasingly uncoordinated and even divergent investment strategies of established operators as well as of new entrants, the emerging network environment will be characterised by strong heterogeneity. Consequently, interoperability will become a crucial factor determining the success of new wireless business models.

Business and market strategies of (coalitions of) firms in different ICT-related sectors will determine whether future wireless solutions will be network-centric or terminal-centric in terms of the distribution of intelligence. Up until now, three different, partly conflicting approaches can be observed: 'service based' (e.g. I-mode, Vodafone live), 'platform based' (e.g. MS Smartphone, Symbian Series 60),

and 'protocol based' (e.g. SMS, MMS). Ad hoc networking may be a disruptive technology in this evolution.

Second, there will be an increasing flexibility of roles and actors. This refers to the unbundling of functions and roles and to their peer-to-peer characteristics. Traditional telecommunication systems, Internet based systems, and emerging new applications will converge. The borders between traditional roles and administrative domains are blurring. An individual user or organization may become service provider (ad-hoc networking), or content provider (e.g. music sharing), or service retailer (peer-to-peer). This raises the question how to integrate different business roles into a single, generic business model.

The physical resources, which are used for a certain communication request, are determined in the activation process of contexts and objects. These physical resources belong to administrative domains where certain roles are assigned. As users act in different contexts, the relationships to the administrative domains involved in a communication process have to be managed. This causes the dynamic assignment of roles and the employment of different reference points, in cases of ad-hoc and peer-to-peer communications implemented without any centralised control. Those dynamic relationships between the users and the objects required for individualised communication service provision will cause new concepts to be implemented, like on-line subscription, micro payment, and the federation between ad-hoc communication environments.

6.2 Pervasive computing

A field closely related to distributed systems and mobile computing is the pervasive computing. The key goal in this area can be reflected by a model of "authorized access to anytime-anywhere-any device-any network-any data". Pervasive computing points to scenarios where we live in and move around environments that are "saturated" with computing and communication capability. Such environments result from the convergence of developments in several fields, namely the distributed systems, mobile computing, smart homes, wearable computing, mobile devices, etc. (Fig. 5).

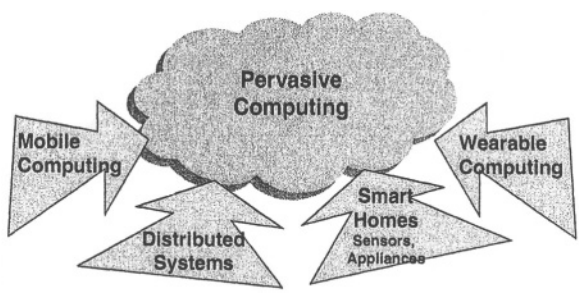

Figure 5 – The advent of pervasive computing

One of the intrinsic design principles of pervasive computing, also a goal in collaborative networked organizations, is the invisibility of the infrastructures, i.e. the "disappearance" of the underlying computing technology from the user's

consciousness, not to be seen and to get in the way of usage, or at least reaching a level of minimal user distraction.

Expected progress in this area is likely to have a large impact at all levels of society, and hence in the way people work and collaborate.

Some important research and development challenges in this area, closely related to the collaborative networks needs, include:

- Effective smart spaces. A space may be any enclosed area, e.g. a meeting room, a home, an airport lounge, a café, or even a well-defined open area such as a courtyard. A smart space shall embed an infrastructure that provides wireless and seamless access to computing and data servers, sensors and smart devices present in the same environment.
- New methods to cope with the heterogeneity of levels of smartness of different environments when users move from one space to another. This requires a new level of adaptability of the software systems and is part of a more global challenge, the context-awareness.
- New concepts and mechanisms for security and authentication. In pervasive environments, access to trusted third parties and public/private key infrastructures does not seem to be the best approach. New methods of authentication must be found and developed.
- Methods to capture and track users' actions and to foresee users' intention. Pro-activity in a smart space requires such mechanisms in order to act effective.
- Surrogate computing methods. In the case of mobile users, the carried (or worn) devices have limited computing capabilities compared to stationary systems and it can be envisaged that public spaces be equipped with computing servers providing computing services to the mobile devices. This raises several technical issues such as trust in the surrogates, load balancing, scalability, etc.
- Privacy and trust. Key features of a pervasive environment such as smart spaces, location tracking, the use of surrogates, or system self-tuning according to users' profile / intent, may represent a threat to privacy of people. Solutions to reach acceptable balance between privacy and user's trust on the infrastructure on one hand, and the seamless pro-active systems behavior on the other hand, need to be found and developed.
- At a more pragmatic level, further convergence of standards (Wi-Fi, Bluetooth, PnP, etc.) is needed.

7. CONCLUSIONS

Information and Communication Technologies progress fast, suggesting new opportunities for development and broad adoption of new collaborative networked organizations. But as a consequence of this fast evolution, technologies and products have very short life-time, what represents a major obstacle for SMEs. Therefore, while learning from the leading edge technology, there is an urgent need for development of a technology-independent reference architecture to provide the base support infrastructures for collaborative networked organizations.

It shall also be realized that most recent developments in terms of basic support infrastructures are either e-Commerce or B2B oriented, and not providing adequate support platform for advanced collaboration in a network of heterogeneous and autonomous organizations (Fig. 6).

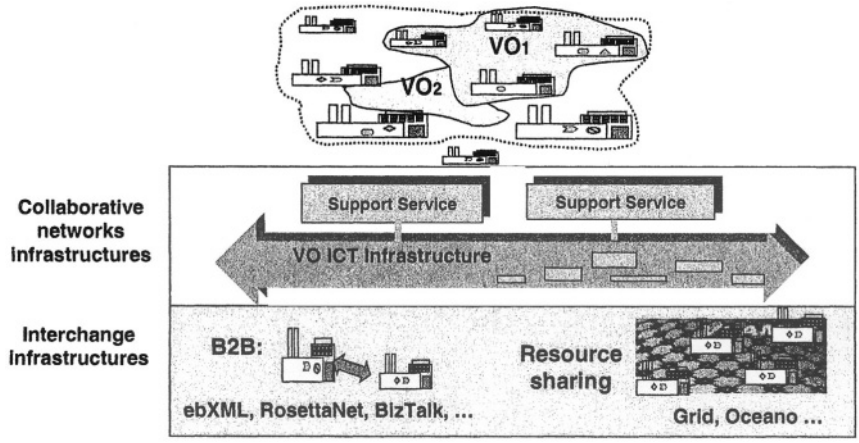

Figure 6 – The need for a collaboration support infrastructure

At present, a positive fact is that there are several important standardization efforts going on in the area of Internet-related technologies, however, there is also the usual danger of the standardization committees / groups becoming too large in scope that may get derailed from the original goals into never ending their tasks and therefore rendering useless.

For designing a collaboration support infrastructure, although based on the knowledge of the leading edge technology, openness and technology-independence should be pursued, it is certainly necessary to provide some mappings to available technologies at each milestone and, therefore, researchers in the area need to continuously follow the major trends / technologies. But this situation should not preclude the research programs from having a clear perspective of their focus, in order to avoid the mistakes of the past when most projects' efforts were too biased by short-term technologies.

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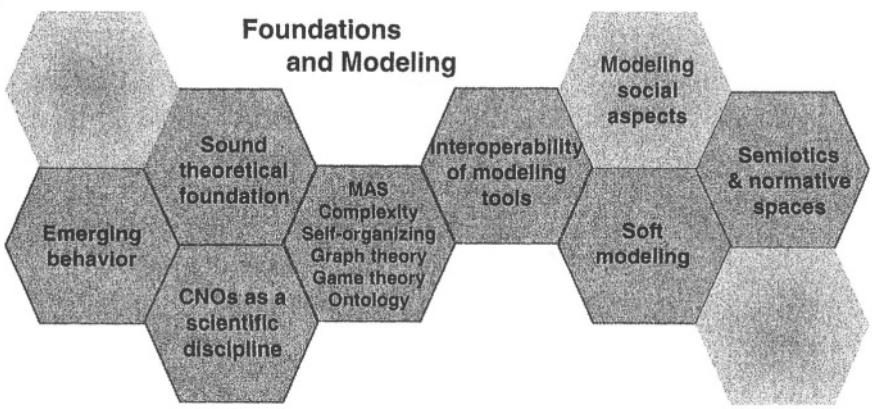
FOUNDATIONS AND MODELING

OVERVIEW

One of the most important findings of the THINKcreative initiative is the identification of the urgent need to invest on establishment of a sound theoretical foundation for CNOs. Departing from the past experiences in CNO research, in most cases characterized by an ad-hoc nature, and realizing the inherent limitations of those approaches, the research community and a growing number of industry visionaries are realizing the need for a second phase of CNO research.

The first two chapters in this part identify some key challenges in terms of establishing a sound and formal theoretical foundation, and suggest a number of disciplines whose results may be taken and adapted as a baseline for the new scientific discipline for CNOs. The following chapters illustrate how three of these disciplines – namely, multi-agent systems, social actor networks, and semiotics – can each contribute to the CNOs and what are the main remaining research challenges and the extensions necessary for each area.

The multi-disciplinary workshops approach of THINKcreative that were the basis for most results presented in this part also provides some indication of how the work in this area shall be organized. Organizing small focused workshops, combining a number of disciplines and involving experts with different background knowledge, was the first step towards the interoperability and integration of different contributions.



As a global summary, the following recommendations were made:

- Understanding and modeling emerging behavior in new collaborative networked organizations is a key challenge and a pre-requisite for the design and development of new CNO support infrastructures and services.
- Establishment of a sound theoretical foundation, based on well argued and verified models and methodologies, is a key requirement for sustainable development of the area of CNOs and its recognition as a scientific discipline.
- In order to establish a theoretical foundation for this area, several contributions can be borrowed from a number of other disciplines e.g. multi-agent systems, complexity theories, self-organizing systems, graph theory, network analysis and game theory, formal engineering methods, formal theories, temporal and modal logic, semiotics, dynamic ontologies, metaphors, and others.
- There is no single formal modeling tool / approach – no single "universal language" – that adequately covers all modeling perspectives / needs in CNOs. Therefore interoperability / integration of different modeling tools and approaches is needed.
- Given the increasing importance of the human aspects in collaborative networks, a new foundation for modeling social aspects is required. The dynamic and fast evolving nature of emerging CNOs, together with recognition of the relevance of social relationships, also calls for a new emphasis on soft modeling approaches.
- Appropriate models shall be developed for handling issues such as duties, beliefs, commitments, behavior, and values. Organizational semiotics is a possible direction for a sound basis for normative spaces in collaborative networks.

EMERGING BEHAVIOR IN COMPLEX COLLABORATIVE NETWORKS

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Fast progress in computer networking technologies and their pervasive use have a catalytic effect on the emergence of new forms of collaboration and new patterns of behavior in collaborative networks. Understanding and modeling these forms and patterns in the context of large, collaborative networks, is a main challenge for which contribution can be seek from a variety of other disciplines addressing complex dynamic self-organizing systems. Several of these areas were addressed in focused workshops of the THINKcreative project and the potential contributions from some of these areas towards understanding and modeling collaborative networks are briefly summarized in this chapter. Recommendations for research actions are identified.

1. INTRODUCTION

This section summarizes the conclusions of a couple of workshops focused on Emerging Behavior and Architecture of Complex Collaborative Networked Organizations, held in Brussels, and organized in the framework of the THINKcreative project. These workshops aimed at identifying and discussing the challenging issues and promising scientific approaches to address the *behavioral issues and potential architecture for complex collaborative networks.*

In recent years the business world has faced many challenges, leading to the emergence of a large variety of collaborative networks enabled by the continuous advances in the information and communication technologies. Advanced and highly integrated supply chains, virtual enterprises / virtual organizations, virtual (professional) communities, value constellations, represent only the tip of a major trend in which enterprises seek complementarities and joint activities that allow them to participate in competitive business opportunities and new markets. In particular for industrial landscapes composed mostly of SMEs, as is the European case, involvement in a collaborative network represents not only a survival factor but also a competitive advantage in face of the turbulent market scenarios. *Market turbulence* in this context is characterized by complexity as well as the speed of change in causal interconnections in the socio-economic environment.

As new collaboration support infrastructures and tools become available, new behavioural patterns emerge, even in traditional collaborative organizations. The concept of *emergence* has been a subject of intense discussion in disciplines such as

philosophy of science, artificial intelligence, theoretical biology, etc. Emergence can be defined as the overall system behavior that results from the interaction of many participants - behavior that cannot be predicted from the knowledge of what each component of a system does. In particular when speaking about an emergent property of a system it refers to what we get when something is more than the sum of its parts. In other words, an emergent property describes a higher level of organization of a system, where its description is not epistemologically reducible to lower-level concepts. It is an emergence when simple/local interactions produce "interesting" (unanticipated) outcomes at the macro-level.

The idea of emergence is therefore used to convey the idea of arising of patterns, structures, or properties that do not seem adequately explained by referring only to the system's pre-existing components and their interactions. In our context the point is to investigate the behavioural patterns that can be observed in complex collaborative networks but are not simply explainable by the mere addition of the simpler individual behaviours of the network members.

After an initial phase in which, mostly biased by traditional business practices, the very first infrastructures and pilot cases were developed, there is at present a vital need to conduct fundamental research in order to understand both the *architecture* and the emerging *behavior of new collaborative organizational forms.* In this direction, and by combining contributions from different disciplines, including complex systems theory, biology, artificial intelligent / multi-agent systems, game theory, and chaos theory, among others, these THINKcreative workshops aimed at the identification and characterization of research challenges, promising approaches, and major goals towards the development of new models and technology support necessary for prediction and management of emerging behavior in future dynamic collaborative networks.

A key purpose at this stage is therefore the establishment of a scientific foundation to facilitate understanding of the collaborative networks *phenomenon* and their behavior in order to facilitate the identification of regulatory mechanisms and norms (and not the traditional control mechanisms). Nevertheless, a better understanding of this phenomenon does not necessarily guarantee a better capability of prediction of its behavior. But getting some insights into the relevant sources and mechanisms of variation will help to estimate which behaviors are more likely to rise and which ones are impossible. Managing or controlling such systems is also difficult, but can certainly be improved once deeper understanding is reached. Furthermore, we shall note that current business ecosystems are not purely self-organizing systems but a mix where forms of centralized planning and control coexist with new evolving organizational forms.

2. KEY CONTRIBUTING AREAS

A number of scientific disciplines and ongoing research topics have been identified as key contributors to facilitating the study of complex collaborative networks.

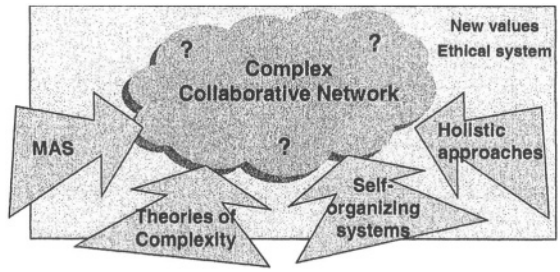

Figure 1 – Key contributors to understand complex CNOs

Multi-Agent Systems

The study of multi-agent systems (MAS) focuses on systems in which many intelligent agents interact with each other. Agents are considered to be autonomous entities, for instance as software programs or robots and their interactions can be either cooperative or selfish. AI researchers have devoted considerable attention to understanding and modeling how societies of agents can be organized and their behavior regulated. Coalition formation, negotiation, brokering, contract negotiation, development of concepts related to norms and institutions, are examples of intense research areas in this discipline [3], [6], [7], [9]. On the other hand, researchers in social sciences and complexity science are adopting the MAS paradigm as a simulation tool to develop and evaluate their models of social organizations. MAS can, therefore be an important catalyst in diverse approaches to model and understand collaborative networks.

The potential use of this approach in virtual organizations has already been recognized by several researchers that represent enterprises as agents and the inter-enterprise cooperation as interactions in a distributed multi-agent system [2]. The initial works however were more focused on the use of MAS as a technology, rather than as a modeling framework. Nevertheless, the recent theoretical work on MAS suggests however its potential contribution to understanding and modeling emerging behavior and in supporting the institutions involved in complex collaborative networks.

Theories of complexity

Complexity theory deals with systems that show complex structures in time or space, often hiding simple deterministic rules. An intuitive notion considers a complex system as a system for which it is difficult, if not impossible, to reduce the number of characterizing variables without loosing its essential global functional properties. The first developments in the area of complexity resulted from the studies in non-linear systems. In fact, more than a single theory, the so-called complexity science represents a set of theories describing how the complex adaptive systems like stock markets, supply chains, ecosystems, and even rain forests work.

A complex system can be understood as any network of interacting agents (processes or elements) that exhibits a dynamic aggregate behavior as a result of the individual activities of its agents. Increased computing power has given us the ability to model the *idiosyncratic* behavior of systems composed of thousands of individual agents.

As Phellan states in [8]: "*at the core of complexity science is the assumption that complexity in the world arises from simple rules. However, these rules (which I term*

'generative rules') are unlike the rules (or laws) of traditional science. Generative rules typically determine how a set of artificial agents will behave in their virtual environment over time; including the interaction with other agents. Unlike traditional science, generative rules do not predict an outcome for every state of the world. Instead, generative rules use feedback and learning algorithms to enable the agent to adapt to its environment over time. The application of these generative rules to a large population of agents leads to emergent behavior that may bear some resemblance to real world phenomena. Finding a set of generative rules that can mimic real world behavior may help scientists predict, control, or explain hitherto unfathomable systems."

Some important characteristics of complex systems include: non-determinism, limited functional decomposability, distributed nature of information, and emergence and self-organization. Emergence is in fact one of the most important properties of complex systems, what makes this paradigm an appealing approach for the analysis of advanced collaborative networks.

Self-organizing systems

Realizing that the *organizational forms* we can identify around us are only a small sub-set of those theoretically possible, the question arises: Why these organizational forms and not the others? Self-organization theory, that is a branch of systems theory also considered one of the development axis of the theory of complax systems, tries to address such question and relates to the process of "order" formation in complex dynamic systems.

The essence of self-organization is that system structure often appears without explicit pressure or involvement from outside the system. Self-organization is understood as the spontaneous creation of a globally coherent pattern out of certain local interactions [5]. In other words, the constraints on form (i.e. organization) of interest to us are internal to the system, resulting from the interactions among its components, and usually independent of the "physical" nature of those components. The organization can evolve either in time or space, can maintain a stable form, or show a transient phenomenon. According to the 'self-organization' theory, order in an interconnected system of elements arises around what are called the 'attractors', that help to create and hold stable patterns within the system. These attractors combine to form a dynamic 'landscape', which determines the behavior of the system.

The field of self-organization seeks general rules about the growth and evolution of systemic structure, the forms it might take, and finally methods that predict the future organization that will result from changes made to the underlying components. The results are expected to be applicable to any other system exhibiting similar network characteristics.

Evolving networks and small worlds

The study of networks is attracting a lot of attention lately. Realizing that we live in a "world of networks" creates the conditions to bring together contributions from different disciplines. From the Internet and the web, to the networks of collaborations (e.g. in research projects), networks of citation of scientific papers, and the extent of communication networks, among others show the central role that networks play in modern society. But we are also part of various biological networks

– neural networks, networks of metabolic reactions, genome and protein networks, etc. [4]. As these networks are not static but rather evolving objects, physicists who are particularly trained to study dynamic systems, namely in the areas of physics of growth, diffusion, self-organized criticality, etc, bring new insights on how to study the evolution of networks.

Graph theory has also made considerable progresses namely in terms of modern architectures of random graphs, clustering and preferential linking of edges and self-organization, small worlds and compactness of networks, etc. All these perspectives represent a growing basis for a new sound approach to study collaborative networks.

Holistic approaches

Most of the past research on virtual organizations was focused on specific topics or particular aspects, which led to a large fragmentation of results. Very often, in their attempt to solve their focus problem, researchers were confronted with a large number of interactions with other areas they had no intention to tackle. The limited resources available to each research project typically created an unsolvable situation –significant progress could only be pursued if a holistic perspective was taken into account, but this perspective could not be afforded.

As a consequence either the results were of limited use or new problems were (artificially) created. In fact a proper understanding of VOs and CNOs in general requires a "multi-worlds" modeling perspective (a holistic approach).

Ambitious research programs must therefore be based on an integrated multi-disciplinary approach and focused on long-term rather than short-term results.

This also raises issues of what should be the profile of researchers that are needed for this study: Experts with a large experience in different domains, a comprehensive background on multiple disciplines, and a clear perspective of the trends. However, visionaries with a comprehensive understanding of the multiple areas and their fundamental inter-relationships, that remain active in research, are difficult to find.

Ethical issues

When discussing new organizational forms and emerging behavior it is important to not only consider the "technical" aspects but also the "values" that shall influence or constrain that behavior. Particularly in scenarios involving different cultural backgrounds and different value systems and where responsibilities tend to be diluted, ethical issues need to be discussed. Some kind of "code of ethics" is a necessity in collaborative networks.

3. MAIN RECOMMENDATIONS

The THINKcreative workshops constituted an opportunity for the presentation of a rich set of ideas originated in different disciplines and allowed live discussions out of which the following key conclusions are derived:

- Future research programs in advanced virtual organizations and new collaborative networked organizations must effectively combine and integrate contributions of multiple disciplines, namely Computer Science and

Engineering, Economy, Sociology and Business Policy and Strategy, Organizational and Management Sciences, receiving inputs from other fields such as Biology, Ecology and Physics, but also taking into account Moral and Ethical issues.

- Understanding and modeling emerging behavior in new collaborative, networked organizations is a key research challenge and a pre-requisite for the design and development of new support infrastructures. The concept of "emergence" itself and the balance of emergent vs. deliberative strategies need to be better understood in this context.
- The various theories of complexity can give some insights on how to approach the analysis of new organizational forms and their emerging behavior. However, we cannot simply adopt models developed in other contexts (e.g. Physics and Biology) as the "human-social" elements are difficult to model, but the methodologies and basic principles researched in the area of complexity represent a promising starting point.
- The multi-agent community has been addressing many problems similar to the ones found in VOs. In fact many aspects of the VOs and their behavior, namely coalition formation and emergent behavior, can be modeled by the MAS concepts and Distributed AI. A closer interaction between the two areas is recommended. In particular multi-agent approaches can bring important inputs to the coalition formation processes, but more work is needed in terms of the social aspects of agency, normative models, and reasoning with uncertainty.
- The concept of meta-agent, a high-level agent devoted to process meta-knowledge, represents a promising approach to help identifying trends and patterns in the behavior of networked organizations.
- More theoretical work is also needed on understanding the roles of leadership (and what kind) and coordination, the scope of vision/mission in virtual organizations, the emergence and establishment of coordination rules and "normative" institutions. Contributions from the areas of self-organizing systems and social order in multi-agent systems seem to be promising.
- There are significant standardization efforts in MAS, namely in the framework of FIPA, but so far still the specific needs of VO have not been addressed – an open opportunity for collaboration between the two communities.
- Knowledge management, as a "horizontal" activity, is certainly required for modeling and managing the complex collaborative networks, but the emphasis must be put on soft modeling (uncertain / imprecise knowledge), multi-level modeling and on capturing the socio-cultural dynamics.
- A multi-worlds / multi-level perspective shall be considered when modeling and designing support infrastructures (addressing the Social / Cultural, Legal / Explicit, Physical) characteristics. In fact it is time for the issues of advanced VOs to be addressed following a holistic approach instead of trying

to solve one problem at a time; the traditional fragmented approaches tend to create new problems whenever partial solutions are put forward

- Simulation and experimental modeling approaches, methodologies and tools need to be developed as a means to help grasping the emerging shapes and behavior of unpredictable evolutionary systems.
- Departing from "enterprise-centric" reference models (e.g. CIM-OSA, GERAM) and trying to understand the collaborative networks might be misleading in the sense that the main aspects of collaboration among autonomous entities are not captured. Therefore, modeling and simulation of collaborative networks require new approaches.
- There is a need to invest on a better understanding the fundamental mechanisms of cooperation and competition and the underlying principles of self-organizing systems. Current work on learning webs can give some insights in this direction.
- Understanding what is turbulence, how to identify opportunities, what are the breeding conditions for innovation, are important areas requiring more theoretical and experimental work.
- Properties being found in advanced graph theory, namely in the areas of clustering and small worlds, together with the contributions from physics need to be integrated in order to better understand evolving networks.
- There is a need for a new ethical approach in the establishment of networked organizations as the traditional economic model is no longer appropriate; current approaches to issues such as anti-trust/unfair competition must be revised.
- Considering that not a single formalism / theory is enough to represent / capture all aspects of emerging organizational forms and behavior, there is a need to explore theories and formalisms from other areas and put them in the appropriate context. The area definitely requires more formal and sound theoretical background support. Nevertheless there is also the need to consider understandability of models and theories in order to have them accepted by industry (namely SMEs).

4. CONCLUSIONS

We live in a "world of networks" of increasing complexity. Of particular relevance are the collaborative networked organizations, showing in different forms, are becoming one of the most promising and relevant paradigms in modern society. Although limited forms of collaborative networks could be observed for centuries, it was the rapid advances of ICT, together with the new socio-economic conditions, that boosted this phenomenon.

In this context, new ways of collaboration, new forms of organizing collaborative networks, new institutions, and new roles for participants are being rapidly developed while not being yet well understood. Market and society

turbulences also make it very difficult to predict the behaviors and successful forms of organization. As a result, patterns of emerging behavior and evolving dynamics in collaborative networks resemble the aspects that have been studied in a number of disciplines such as multi-agent systems, complexity science, self-organizing systems, etc. Therefore important contributions can be borrowed from these other areas as a starting basis to establish a sound theoretical foundation for collaborative networks.

Nevertheless important research challenges are ahead of us and a strong interaction among various contributing disciplines is necessary. As a first step, a practical evaluation of the adequacy of existing theories / paradigms, by mapping their features into the CNO elements, needs to be done. As a second step, adaptation / extension and integration of models and approaches needs to be pursued in order to capture the various aspects of emerging CNOs.

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FORMAL MODELING METHODS FOR COLLABORATIVE NETWORKS

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A sound theoretical foundation, based on well argued and verified models and methodologies, is a key requirement for the progress in the advanced collaborative networks area, namely as a support for decision-making, performance measurement, assessment and improvement, breakthrough ICT support tools development, and elimination of myths that populate "e-world". In order to establish a sound theoretical foundation for this area, contributions can be borrowed from a number of disciplines. Some of these areas are identified and some recommendations are made for further research.

1. INTRODUCTION

After an initial phase in which in spite of the considerable investments on Virtual Organizations, most of the approaches were highly fragmented and case-based, it is now urgent to consolidate and synthesize the existing knowledge, setting a sound basis for the future. One of the main weaknesses in the area is the lack of appropriate **theories**, consistent paradigms and **formal modeling tools**. Dramatically enough there is not yet a common definition of basic concepts such as virtual organization, collaborative networks, or virtual enterprise.

Particularly in Europe, but also in the USA, Australia, and some other countries in Latin America and Asia, considerable efforts have been made in this area and a large community has been established, but in many cases the pressure to have quick developments hindered the approaches. Due to the youth of the area, but also due to the turbulence caused by the very rapid evolution of the Internet-related technologies, most of these efforts are of ad-hoc nature, their results are hardly re-utilizable, and very often do not survive the short-term of a particular technology wave.

One of the findings of THINKcreative initiative, through the multiple workshops and interactions with a large number of experts from different sectors, is that there is an urgent need to consolidate the existing knowledge base and launch a sound theoretical foundation for this area.

Like in any other scientific discipline or engineering branch, collaborative networked organizations (CNOs) require the development of formal theories and

models, not only as a help to better understand the area, but also as the basis for the development of methods and tools for better decision-making. In fact decision-making in all phases of the future CNO life cycle need to be based on well argued and verified models and methodologies. These models and methodologies constitute the basis for the ICT-based support for business and organizational development and operation, as well as the base for education, training, and active operation of CNOs.

Some theories and paradigms defined elsewhere have been suggested by several research groups as promising tools to help understand and characterize emerging collaborative organizational forms. Examples are: multi-agent theories, coordination models, federated systems paradigm, game theory [10], complexity theory, graph theory, etc. More recently researchers are also starting to look into the "soft computing" area in order to find suitable approaches for modeling aspects related to human behavior in collaborative organizations and to handle the issues of decision making and behavior management in the contexts of incomplete and imprecise knowledge.

Two THINKcreative workshops were held in Lisbon and Funchal in Portugal and a panel was held in association with the BASYS'02 conference in Cancun, Mexico. Those events discussed such issues, contributing to the identification of potential useful modeling approaches and required research on base theories and modeling tools for collaborative networked organizations. The participants were invited to organize their contributions around the following two motivating questions:

1. Which promising paradigms / tools are out there to model emerging collaborative organizations?
2. Which fundamental research is required on modeling formalisms and tools?

Next sections summarize the main conclusions and recommendations that were resulted in these events.

2. SUMMARY OF APPROACHES

2.1 General

During the last decades, research in Europe (and partially in other geographical regions) has become too pragmatic, focused on short-term results, without enough attention to the fundamentals. Meanwhile a large number of challenges and open areas of research are identified that emphasize the need for formal modeling and definitions of different CNO concepts, among which the following can be mentioned:

- A major challenge in collaborative networks is how to model and reason about social actors networks; how to combine "hard social theory" with "soft engineering modeling".
- Network dynamics in terms of reconfiguration, represents a multi-dimensional problem that requires qualitative and quantitative modeling and reasoning approaches.

- The current few attempts to produce reference models for VO are not formal. There is a need to design several rigorous (i.e. formal) models. In particular there is a need for an algebraic specification of a reference model. There is also a need for reference models integration /interoperation and for the definition of metrics and certification criteria associated to reference models.
- The introduction of new "social bodies" (e.g. e-notary) may have an important effect in shaping the emerging structure and behavior of a collaborative organization. Modeling (and being able to "forecast" such phenomena) is a challenge.

Most engineers nowadays ignore what a "formal theory" is. On the other hand, the use of a formalism does not necessarily represent the existence of a formal theory. In order to establish a sound theoretical foundation for collaborative, networked organizations, the approach should not necessarily be to invent "new" formal methods and languages, but rather to adapt the existing ones (and understand their applicability). As candidates in such studies the following paradigms and approaches among others are considered close and relevant:

- Graph theory emerges naturally as a basic support theory for Virtual Organizations.
- Organizational Semiotics and normative models (e.g. deontic logic), being developed in the multi-agent community represent powerful tools to model collaborative networks, including the issues of sub-contracting, negotiation, delegation.
- Visual modeling approaches are important as communication tools and also as a pragmatic approach to facilitate the understandability of models, namely in SME contexts.
- Complexity theories address several problems that have a good match with the collaborative networks, namely the "small-world" regime. Examples of addressed problems by these theories include the following: which behaviors can emerge in a network with a given structure? which measurement tools & criteria are to be considered? which relationship between collective and individual dynamics are relevant?
- One important finding of the theory of complexity is that the structure of the organization (form and function) does not depend on the goals but rather on the method - basic principles.
- Dynamic and distributed approaches for ontology creation are likely to play an important role in VOs.
- More theoretical work is also needed on understanding: the roles and kinds of leadership and coordination, the scope of vision/mission in organizations, the emergence and establishment of coordination rules, and the "normative" institutions.

2.2 Contribution from different disciplines

For the discussed areas of problems and approaches during the three THINKcreative workshops, the main findings can be summarized as follows:

Potential applicability	Limitations & Challenges
Formal theories and modeling of dynamic networks	
▪ Solve design problems: architecture, protocols, network creation ▪ Specify systems, verify specifications according to correctness and completeness ▪ Test and verification implementations versus specifications or standards	▪ Lack of knowledge of formal methods in the current engineering community ▪ Need to consider developments in communication networks
Graph theory	
▪ Represent networks of relationships – topology, routing, activity, flow ▪ Perform computations on flows ▪ Optimization	▪ Basic theory is very rigid - needs extensions to represent non tangible, qualitative relationships (fuzzy dimensions), and multi-criteria
Formal engineering methods	
▪ Best applicable to description of - operational behavior of CNO - formulating operational plans that bind partners (consumers/suppliers) in CNO - verifying formally that the plans are indeed satisfied by the operational behavior ▪ Economic and social aspects cannot be represented.	▪ Difficult to develop and understand ▪ Lack of intermediate-level formalisms linking the abstract approach to direct software development ▪ Need practical application methodology ▪ Need methods to bridge the gap between abstract formalism and IT implementation
Semiotics, normative models and multi-agents [4][5][8]	
▪ Model responsibility relationships and commitments ▪ Prescribe norms and roles, legal support ▪ Capture system requirements	▪ Reasoning in deontic logic may lead to paradoxes; difficult to automate reasoning ▪ An promising approach: integration with agent logic
Network analysis and game theory [10]	
▪ Non cooperative game theory: good for selecting partners, sustaining cooperation and trust ▪ Cooperative game theory: distribution of responsibility and resources ▪ Network exchange theory: coordination, efficiency, power relationships; maintenance of ties and reputation	▪ Practical results are not available yet ▪ Evolving structures generate emergent responses so an updating of the model based on continuous data collection would be necessary ▪ Weak capture of subjective relationships
Temporal and modal logic	
▪ Model the operational phase aspects ▪ Synthesis of processes	▪ Complex, as any formal method ▪ Need to integrate structure descriptions
Metaphors [7]	
▪ Quick description for human	Risk of taking metaphors too strictly

communication (a possible help in expressing complex ill-defined concepts) ▪ Use in early stages (conceptual design)	▪ Need further evaluation and research in consistent understanding in the creation and interpretation of metaphors ▪ Need to combine with formal methods
Theories of complexity [9]	
▪ Analysis of self-organizing behavior ▪ Learn how to manage chaotic dynamics ▪ Insights on VO behavior ("small-worlds")	▪ Models from other domains (e.g. biology, physics) are difficult to apply to VOs ▪ Need further work on complex systems with social actors (humans)
Dynamic ontologies [6]	
▪ Unlike static ontologies, dynamic ones can capture the evolution of mutual understanding among members of the network.	▪ Building them is still more of an art ▪ So far, only first limited experiences on distributed and evolving ontology creation and interoperation

In addition to the above theories and approaches, a number of other possibilities, e.g. the models developed in the telecommunications area, might be useful in this context. Other examples include the *transaction-cost approach* [2], [11] and the *resources dependency theory* [2]. Nevertheless, the purpose of THINKcreative was not to do the actual research work, rather to identify the needs and promising approaches, and making recommendations. It will be up to the future research projects to make a more comprehensive assessment and adaptation of all potential contributions coming from other disciplines.

Somewhat away from the scope of formal models, but nevertheless an important modeling tool, are the metaphors, as addressed above. As stated in [7]: *"Metaphors and other mental models provide a means for individuals and, ultimately, organizations to create and share their understandings. These mental models establish images, names and an understanding of how things fit together. They articulate what is important and unimportant ...the models must be articulated and accepted in the organization for them to be effective ... In the context of such models, believing is seeing."*

3. INTEROPERABILITY AMONG METHODS

Collaborative Networked Organizations (CNOs) can be discussed from multiple perspectives. There is no single formal modeling tool / approach that adequately covers all perspectives – no "universal language" for all problems. Even for one perspective in CNOs, there might be a need to use more than one tool. Therefore interoperability of different modeling tools and approaches is needed for a comprehensive definition and modeling of this paradigm.

Following are the main points discussed in the THINCKcreative workshops and the actions that were suggested during the two brainstorming sessions dedicated to this issue. The actions represent a set of steps that can assist researches with their complex modeling task. Each action is represented below as A1, A2, etc., including some examples to follow.

A1. Identify the main *purposes* and required characteristics for modeling CNOs:
Examples of *purposes*:
- to describe and understand CNOs
- to engineer new business processes for CNOs,
- to measure the Performance of CNOs
- to reconfigure CNOs, (also included in the last one)
- to support the entire life cycle activities of the CNOs
- to support the states, actions, structure, coordination, etc.

After the identification of the modeling purpose and the required characteristics, then select the most applicable modeling tool(s) for the purpose. Namely, the already identified modeling tools form a "shopping list". A mapping between this shopping list and the modeling purposes shall be elaborated.

A2. In order to characterize the modeling needs, some kind of "meta-model" can be developed or adapted and used, in order to uniformly define the criteria and specifications of each of the disciplines related to the CNO. Perhaps a canonical "requirement specification tool" can be used here.

A3. As a pragmatic approach to reach interoperability among models, we should start with bilateral work for each two pairs of inter-related modeling approaches, according to the mapping defined in A1. This work in pairs will give the opportunity to digest the commonalities between every two models, and to identify the necessary extensions. The integration of any two approaches faces hard semantic difficulties. If necessary, the bilateral activities can then be extended to include three or more inter-related subjects.

A4. The emphasis should not be on inventing new formal methods for CNOs, but rather on adapting the existing ones and understanding their applicability.
There is a need to take advantage of the available technology at each stage, but as technology changes fast, reaching "technology-independent models" is a must.

A5. Define some "formal method" or systematic approach to assess the modeling tools and their appropriateness for the main purposes, in order to be able to make an adequate selection.

A6. As a complement to A1, elaborate a list of case studies for using different formal models in different cases and for different purposes, as a first step to learn and assess the modeling tools, towards a more general formal modeling approach.

A7. Elaboration of multi-facet reference models for CNOs is recommended. However, the concept and definition of a "reference model" itself needs to be first better understood.

A8. Improve the fundamental knowledge on formal methods, theoretical foundations, and philosophy of science (which have been lost in most engineering programs). One possibility: establishment of an international PhD program on formal methods.

4. CONCLUSIONS

As a result of the various presentations and discussions held during these workshops it seems there is a consensus among the participants for the urgent need to launch research initiatives towards the establishment of sound theoretical basis for the area of VO/CNO. This basis is a fundamental pre-requisite for further progress in this area and even for its recognition as a scientific discipline.

It is also clear that there are a number of disciplines and theories out there that have produced a number of results with potential application in VO/CNO. These results are clearly not of an immediate application, but may represent a starting basis that needs to be assessed through a number of focused experiments.

In addition to the theories and approaches discussed, a number of other possibilities (e.g. the models developed in the telecommunications area) were briefly addressed at the workshops. Nevertheless it shall be taken into account that the main purpose of THINKcreative was not to do the actual research work but rather to identify the needs and promising approaches, an to make recommendations for the areas of future research. It will be up to the future research projects to make a more comprehensive assessment of all the potential contributions coming from other disciplines.

After various meetings devoted to the topic of theoretical foundations and formal models, it became clear that future research in the area of VO/CNO requires contributions from a wide variety of disciplines, requiring thus a high level of multi-disciplinarity. It is, however, difficult to "gather" all adequate competencies into a single consortium, as experts naturally tend to "cluster" around the people of the same area. One possible solution could be to have a (small) coordinating consortium that would resort to the contributions of a wide number of associate (external) experts invited to participate in research on a short-term basis. Each one of these external experts could belong to and represent a focused task / experiment and also participate in the consensus building workshops. The permanent coordination team should plan the tasks / experiments, "assemble" different approaches, and elaborate conclusions. The alternative would be to gather a very large consortium in order to cover all relevant fields of expertise but this would be more difficult to manage, more resource consuming, and more challenging to reach any consensus.

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AGENT TECHNOLOGY FOR VIRTUAL ORGANIZATIONS

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The contribution shows the analogy between the area of multi-agent systems and virtual enterprises. The main idea of this chapter is that many solutions developed in the multi-agent area can be successfully reused for the virtual enterprise purposes. E.g. the wrapper-based architectures suitable for system integration, knowledge capture and maintenance, definitions of alliances and coalition and algorithms for their automatic creation, team action planning, methods for keeping private, semi-private and public knowledge separate, techniques of the meta-knowledge processing, as well as standards for communication and negotiation can be immediately re-used in the field of virtual enterprises. On the other hand, the available ontology structures or IT platforms are not adequate for the VE purposes. It is necessary to develop quite a new IT platform satisfying much more demanding requirements for knowledge management in virtual enterprises. The same is true for the knowledge ontology structures. Role of agent-based simulation for the VE area is rather stressed.

1. INTRODUCTION

The agent technology, which was briefly overviewed in the Chapter5.3, represents a good paradigm and a motivation source for representing, simulating and solving of many tasks and problems connected with the virtual enterprises. It provides a clear encompassment towards development of an adequate IT infrastructure supporting the area of virtual enterprises. This infrastructure is expected to support the whole life-cycle of a virtual enterprises: it should enable automatic creation, maintenance, reconfiguration, evolution as well as dissolution of virtual enterprises. Such an infrastructure is expected to be based on well-defined standards and consisting of quite natural building blocks.

Virtual enterprise – is understood as a *temporary or semi-temporary network of*

units, which communicate and cooperate to achieve shared goals and to share the achieved revenues – can be studied from the point of view of a certain analogy to the agent-based systems. Unfortunately, both the research communities, one of them working in the field of virtual organizations and the other one in the field of agent-based systems don't interact enough. The VE community is not aware of the results achieved in the area of agent-based research.

This communication gap should be overcome to speed up the IT development processes in the area of virtual enterprises: *Why not to explain the structure, behavior, knowledge handling and sharing principles suitable and desirable for VEs in the MAS terminology? Why not to use the MAS techniques and tools to support and in many cases to extend the infrastructural horizons for VEs?*

In this chapter, we would like to show the key analogies between the VEs and MAS as well to discuss potential application of MAS methods for simulation of behavior of VEs as a motivation for the follow-up research.

2. ANALOGY BETWEEN MULTI-AGENT SYSTEMS AND VIRTUAL ENTERPRISES

Let's consider each company in a VE to operate autonomously, carrying out its relevant duties locally, communicating and exchanging information with the others just when needed. Such a company wants to have the right to join and leave the VE freely, but it understands, that it should satisfy generally valid rules of behavior. In an ideal case, the VE is able to operate in a turbulent environment and is able to react to unpredictable situations by e.g. automatic re-configuration or extension/reduction of its capabilities and resources.

Let's try to formulate the above-mentioned analogy in more detail, discussing potential role of equivalent elements or functionalities developed or simulated in the area of MAS on one hand and expected to be achieved in the field of VEs on the other hand:

1. Each company can be considered as an **autonomous unit,** as an agent able to carry out specific (usually very complex) functions.
2. Each company entering the VE should register with a central registration unit which administers the **"white-pages" list** - a list of all agents, their physical locations and the ACL language used. The **"yellow-pages" list** - a list of agent's services and capabilities – can administered in a decentralized way (e.g. in the case of a flat, temporary networks).
3. Each member of the VE network is usually informed – at least in the extend needed for participation in the network – about the capabilities and resources of the others. This knowledge is usually concentrated in the business planning and scheduling departments, which play the role of acquaintance models in the MAS terminology. Let's stress that the **"social" knowledge** contained in the acquaintance models is extremely important for an efficient operation of the VE as a whole.
4. Standardized way of knowledge and data exchange among the individual companies in the VE should be ensured by an **interoperable IT infrastructure.** The IT departments of the companies responsible for

maintaining this infrastructure as well as for the correct format of messages exchanged, play the role of the **communication part of the wrapper** in the MAS terminology.

5. The processes of the VE formation as well as the joint planning and scheduling activities are based on jointly known – at least within the companies willing to create the VE - **negotiation rules and scenarios.** These are very similar (or identical) to those called **protocols** (like e.g. CNP) or **auctions** (e.g. Dutch or sealed) in the MAS domain.
6. The highly specialized members of a virtual enterprise, like **professional network organizers,** can find easily their counterparts in the MAS community, e.g. various middle agents, brokers etc. The negotiation and brokering algorithms proved to be useful in the MAS area can be used to formalize (and later to automate) the corresponding processes in the field of virtual enterprises.
7. **Alliances** represent groups of companies, which are **ready** to cooperate and **to create a virtual enterprise** in order to solve a particular task, customer's order or project. The members of an alliance exchange and update a certain portion of their knowledge on a regular basis.
8. The entities which observe the activity of the network and which can influence the rules of operation or policies set in the network (like e.g. chambers of commerce, regional authorities, tax office, or new types of "normative institutions") can be represented by the **meta-agents** (either passive or active). The meta-agents could be also introduced by the virtual enterprises themselves as tools helping to detect the less efficient parts or bottlenecks of the network as well as providing advice supporting the self-evolution of the virtual enterprise in the desired direction. They are – as a rule – able to learn from their own experience. The other function can be offered by the meta-agents, namely the self-reflectivity, which can be used by the VE members to understand better the processes appearing within the frame of a VE from the global point of view.
9. The processes of the VE creation are analogous to **coalition formation processes** in the MAS domain: Usually there is a group of companies willing to cooperate sharing necessarily a certain part of the company confidential knowledge (this group might be labeled as an alliance and the shared knowledge as a semi-private in the MAS terminology). The alliance members negotiate the opportunity to create a VE for a given specific task (in MAS terminology: **to create a coalition),** there is one company overtaking the role of a VE leader **(the coalition leader** in MAS terminology). Once the VE is set, it is necessary to develop a joint production/business plan and, later, schedule **(team action planning)**.
10. Virtual enterprises could use **the mobile agents** as well, e.g. for market research or for evaluation of potential members of the alliance. The mobile agents would move, in this case, to the individual customer's or partner's server to evaluate the relevant data and to inform the alliance/coalition partners about the results of evaluation.
11. The concept of **knowledge sharing,** classification of knowledge into **public, private** and **semi-private knowledge** in the way as developed in MAS has got a high potential in the field of virtual enterprises. The requirements for keeping

confidentiality of agents knowledge and preventing knowledge disclosure as much as applying specific **security principles** used in the MAS area can be re-used in the virtual enterprise domain as well (Vlček & Zach, 2002).

3. ROLE OF AGENT-BASED SIMULATION

When considering the principles mentioned above, it is clear that the agent technology can be explored in designing simulation tools and applications for the VEs with advantage. It is necessary just to decide which entities will be represented as a single agent, to define the specialized functionalities/units (like meta-agents, brokers etc.) and the corresponding bodies, which will represent them in the MAS system. The agent-based simulation could be used e.g.:

- to **predict the behavior of the VE** as a whole. The fact that there is no central unit in a VE or MAS represents a critical barrier in a wider applicability of both the MAS and VE ideas. The economists, designers and end-users are simply afraid of loosing control over the emergent behavior, which might occur in the community/network without central elements. They are afraid of stability and convergence of such a behavior. Simulation can significantly help to understand the internal processes in the community. As a matter of fact, the simulation runs can help to detect patterns of emergent behavior, to understand their nature and to find optimal protection against the dangerous, not desirable behavioral patterns.
- to **predict and test the optimal scenario for the VE development,** to understand better, which type of the VE satisfy in the best way the requirements of the market or needs for the problem at hand (before the implementation or creation of a VE),
- to select the **most optimal negotiation framework and strategy** for each of the partners,
- to **link directly the simulation with real emergent processes** in a VE environment enables to use the simulation tools repeatedly in the real-time activities. This capability means that whereas a part of the VE is engaged fully in the real-life activities, the remaining part can be just simulated. The shift of the borderline between the simulated (in more precise terms "emulated") and real part of the VE can be carried out in a quite smooth way. This would help to speed-up the initial "commissioning" processes significantly.

4. EXTENDING THE CONCEPT OF VIRTUAL ENTERPRISES

The design concept of virtual enterprises can not only get inspiration from the MAS field, but jointly with the MAS field they can suggest a unified framework for the extended enterprise.

Cross-integrated enterprise (CIE) – is a (virtual) enterprise where the collaborative units are all members of the control, manufacturing and supply chain considered horizontally (ranging from the control to business processes) across the entire enterprise (manufacturing machines and cells, workshops, departments, enterprise divisions, suppliers and customers). The cooperative units from different parts of the cross-integrated enterprise communicate "peer-to-peer" and the planning, scheduling and decision-making processes are organized in an integrated way, across the whole CIE. The same agent-oriented philosophy can be used on different levels in the cross- integrated enterprise (Shen & Norrie, 1996):

- on the lowest level of **real-time holonic control**; this level is tightly linked with the physical manufacturing devices. The holons create holarchies (Koestler, 1967) and are sometimes wrapped into higher-level holonic or software agents, which are responsible for higher level negotiations needed in the case of a failure or when changes in the manufacturing plan suddenly occur (Deen, 2003),
- on the **shop-floor and company decision-making level**, the **agent-based planning and scheduling** may be introduced. Being partially extended to an extra-enterprise planning and scheduling (when the internal shop-floor planning is permitted to be directly influenced or carried out by entities outside the company, e.g. by preferred customers of suppliers), an important technological step based on agent-based approach towards the virtual enterprise can be done.
- on the level of the **virtual inter-company cooperation** when appropriate IT platform, standard agent services, automated negotiation scenarios etc. are used to plan the coordination, cooperation and global functional integration among different companies – members of the VE.

When the same philosophy, stemming from the agent-oriented approach is used across the manufacturing and business process from the individual machines up to the virtual enterprise as a whole (in the horizontal direction) (Glanzer et al., 2003), **new interesting potential interactions do appear**: E.g. the holonic agents from different companies can talk to each other asking for changes of some manufacturing parameters, the business department of one company can send data directly to the scheduling mechanism of a specific workshop belonging to a partner's company without the need to inform the managerial level, the manufacturing holons can directly warn the purchase/sales department avoiding classical hierarchical communication channels in the plant etc. To enable this across the company, peer-to-peer messaging and interactions requires, of course, the development of appropriate message portfolio as well as of the corresponding knowledge containers (acquaintance models) located in individual agents.

5. EXTENSION OF MAS TECHNIQUES FOR THE VE NEEDS

It is also possible to detect the topics, which are not solved by the MAS technologies in the extent needed for the virtual enterprises yet, e.g.

- The knowledge seems to be much wider and diversified in the case of VEs. The **adequate knowledge capture and management methods** needed in virtual enterprises, where the extent of the knowledge exceeds the knowledge usually handled by the "classical" MAS systems by several orders, are still missing. The knowledge management approaches in the current MAS systems are just toy examples from the point of view of VEs. It is necessary to develop standardized, quite new techniques for capturing the vast volumes of knowledge, maintain it up-to-date and explore it in an efficient way.
- The current experience concerning the **knowledge ontology** representation, maintenance and exploration in MAS just helps to understand how important the common shared ontologies will be for the virtual enterprises and how important will be the mutual transformation among different ontologies. Simply, the *ontologies in the MAS area are not developed enough to provide a direct support to the VE solutions.*
- FIPA **standardization** efforts demonstrate one possible way, which the VE area should go to achieve the full interoperability. *The FIPA standards developed and approved are not ready to support the interoperability in the area of VEs.* But, a very intensive cooperation with the FIPA organization might speed-up the process of introducing interoperability principles in the area of VEs, either within or outside the frame of FIPA consortium. Considering other technologies e.g. web services is recommended.
- There are already several **MAS platforms** available, majority of them are FIPA-compliant (JADE, FIPA-OS, JACK etc.) – see overview in (Vrba, 2003). *Unfortunately, none of them is directly applicable in the field of VEs because of several reasons*: The message structures and ontologies are not rich enough, they are underdeveloped from the point of view of VEs' needs. It is even not clear whether the current FIPA standards can be extended and modified in a way, which would be acceptable and reasonable for the VE area. But, in any case, FIPA results provide good inspiration and outline the initial pathway for the VE platform research.
- Automatic or semi-automatic algorithms for **coalition formation processes** are still underdeveloped. In majority cases, they are based on a game-theoretic approach (Shehory & Kraus 1998) which is acceptable only for VEs with a strong central partner. Moreover, future coalition formation algorithms should consider more aspects in parallel, including the opportunity for each of the partners to participate in several, maybe even competing coalitions (VEs). The problems of **coopetition** (mutual cooperation of two units in certain projects and competition in the others) naturally appear in the business practice of today, but there are no adequate algorithms in both the MAS and VE areas available yet. Especially, handling the company confidential knowledge in the case of coopetition represents a hot topic for investigation.
- MAS theories offer a well developed formalism for **trading optimization** in the form of auctioning and bargaining. These approaches are very suitable for single deal interaction (even-though there are variations of contract-net-protocol that allow clustering of deals) (Oliveira and Rocha, 2002). In VE we will need such technologies that will allow optimization on top of the optimality of one specific deal as much as the value of long-term business relationships in a supply chain.

- One of the most important, sometimes crucial aspects when creating and running a VE is the mutual **trust and experience from cooperation** in the past as well as *reputation* of each of the partners. All these aspects can be addressed by the MAS concepts, but not so many practical solutions can be seen yet. It is just because the aspects of trust and reputation were located out of the interest of the MAS research. Investigations and experiments in this direction would be appreciated (Luck et al., 2003).
- The **algorithms evaluating efficiency of cooperation** in a VE are still missing. An overview of available metrics (Goranson, 1999) documents that significant development in this direction is needed. The MAS area should provide theoretical background and frameworks for such metrics algorithms. The metrics themselves are expected to be domain specific and knowledge intensive requiring additional knowledge from the given VE sub-area.
- Capabilities to **reconfigure and optimize the VE performance** in the case of a failure or partial damage and capability to set-up the new optimization criteria autonomously should become quite natural for VEs of the future. The first practical experience in solving similar tasks of system reconfiguration has been gathered in the field of holonic manufacturing (Maturana et al., 2002). For the purpose of self-adaptation and performance improvements in the everchanging environment, the principles of self-understanding, self-consciousness and self-reflection should be intensively researched. The first step in this direction seems to be the research aimed at meta-agency and meta-reasoning.

The topics mentioned in this brief summary represent just the most important issues to be investigated. The MAS community realizes fully the lack of research in majority of the above mentioned issues as all of them are – in this or other form - included into the roadmap for Agent Based Computing (Luck et al, 2003) which was prepared as an important, future-oriented document of the AgentLinkII consortium.

6. CONCLUSIONS

The results achieved in the MAS area provide an **excellent motivation for the development of solutions for virtual enterprises,** which would be based on similar principles and technologies **(Mařík** at al., 2002). Some principles and techniques can be re-used immediately, some of them are still underdeveloped and their current state of development just encompasses the future trends.

The VE community lacks in an efficient IT platform, specially developed for the area of virtual enterprises. (Camarinha-Matos et al., 1999). The general IT technology is mature enough to enable to develop such a platform (Cunha et al., 2002), but the research, development and namely the investments into this platform should be done by one of the major IT players. This is the only chance to get an adequate, high performance, and thus applicable, platform soon. The main problems of developing such a platform seem to be

- **the ability to manage exploration of vast volumes of highly distributed knowledge** (some parts of it being considered as private or semi-private),

- **interoperability** of the communication interfaces which would enable rich communication, which would be technically achievable and accepted by everybody.

A very tight cooperation of both the MAS and VE communities is needed to develop adequate agent-based solutions satisfying the VE requirements.

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MODELING SOCIAL ASPECTS OF COLLABORATIVE NETWORKS

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Modeling approaches are necessarily grounded in epistemic and ontological assumptions about the domain in question. Even in predominantly technical areas, these assumptions are Influenced by the worldview of methods, designers and users, being strongly shaped by cultural and social factors. Moreover, modeling social aspects of collaborative networks involves another level of complexity: the subject itself. In fact, we have to decide which social aspects are to be modeled and how they will be modeled. Both decisions are biased by cultural and social influences. In this work, we have tried to approach some fundamental issues of modeling social aspects of collaborative networks, taking into account these particular concerns.

1. THE PURPOSE OF SOCIAL MODELS FOR COLLABORATIVE NETWORKS

A collaborative network may be viewed as a physically decentralized social network made up of individuals who form a community but are not members of the same formal organization (Howard, 2002). These organizational networks may be called for example 'communities of practice' in sociology (Bijker et al., 1987) or 'knowledge networks' in management (Podolny and Page, 1998; Uzzi, 1996). A range of methodological approaches have been used to study these social phenomena (depending of course on the aim of the study), but every approach is built upon a set of models used to explain or just to describe some of their relevant aspects.

Here we are particularly interested in collaborative networks where interaction is strongly mediated by information technology and systems. Although the models used in studying these networks have in general an emphasis on technical issues, we know that social and organizational issues may also play a very important role.

In practical terms, the application of social models for collaborative networks can be divided into the following categories (not mutually exclusive):

i) theory building - mathematical and simulation models are used to describe and simulate aspects of the creation, operation and dissolution of collaborative

networks, with the purpose of helping researchers to create knowledge and theories about the social structure and dynamics of those networks;

ii) organizational and technical design - conceptual, formal, mathematical and simulation models (or a combination of these) are used as descriptive and analytical tools in a process of designing technological and organizational structures and processes in collaborative networks;

iii) management support - conceptual and formal models (or a combination of these) are used to help the actors involved in collaborative networks to manage their relationships in terms of knowledge sharing and decision support.

2. CURRENT SOCIAL CONCEPTUALIZATIONS OF COLLABORATIVE NETWORKS

From an engineering perspective, modeling social aspects of an enterprise, as a research topic, has been addressed since the 80's, mainly under the broad area known as Enterprise Modeling (EM). As part of a comprehensive engineering approach, we may consider that EM already dealt with some forms of collaborative networks, even if it was in a quite basic way. However, these modeling methods did not adequately tackle the social and organizational aspects of enterprises and networks of enterprises both in terms of methodological openings and ontological commitments, viewed as criteria useful to evaluate engineering focused methods (Soares, 2000).

Methodological openings have to do with the co-operation with other methodologies i.e., with the features of a EM methodology to incorporate links to other methodologies, particularly to those that are socially and organizationally oriented. Methodological openings do not reflect any need or dependence on other methodologies, but only a possibility of information exchange.

Ontological commitments have to do with the capability of modeling languages to represent the enterprise's social and organizational knowledge, that can be evaluated by making use of the ontological commitment concept, defined as "the partial semantic account of a given domain's intended conceptualization". This basic ontological commitment defines what is possible to model with a given modeling language, in socio-organizational terms, namely by clearly making a distinction between the representation of organizational structure and organizational action.

The following table summarizes the evaluation of some well known EM methodologies developed during the 90's.

	Methodological opening		**Ontological commitment**	
	methodological links	**modeling links**	**social structure**	**social action**
CIM-OSA	*weak*	*moderate*	*moderate*	*weak*
GRAI/GIM	*weak*	*weak*	*moderate*	*weak*
PERA	*strong*	*n/a*	*n/a*	*n/a*
ORDIT	*n/a*	*moderate*	*moderate*	*moderate*

(n/a - not applicable)

From this table it is possible to conclude (Soares, 2000) that the modeling of social and organisational aspects of an enterprise has been in general rather poor.

A clear enhancement comes from viewing collaborative networks as socio-technical systems (STS). Although obsolete in some aspects, this conceptualization is still able to provide a general and flexible conceptual platform from where more specific, innovative and useful approaches can be derived. By its own nature, STS embraces a systemic epistemology, not able to adequately respond to the complexity of today's dialectic between the technological and the social. The recent interest in networks and networking, has therefore revealed the need to address some questions raised by STS, in a more challenging and specific way.

3. NEW FOUNDATIONS FOR MODELING SOCIAL ASPECTS OF COLLABORATIVE NETWORKS

There has been in the last years, a growing research interest on the networking concept as applied to management and technology. The general theoretical framework of the networked society (Castells, 1996) strongly supported by a set of comprehensive empirical studies, was the basis of several research programs developing and using network-centric theories and methodologies. In business and technology, approaches based on smart organizations and collaborative networks, are being extensively used. In particular, this is the case of social network analysis and actor-network theory (Lamb and Kling, 2001).

Social network analysis builds on a long tradition of social-structural perspectives. Nevertheless, there was recently a resurgence of this approach (Burt, 2000; Zack, 2000; Lamb and Kling, 2001). Particularly in networked or virtual organizations this approach is well suited, as social structure is not bound to the formal organization and the analysis may apply naturally to inter-organizational relationships. For example, the work of Wellman et al. (1996) on cooperative work and tele-work is directly based on social network concepts. Gitell's work (2000) also highlights the role of social networks and the use of various enabling technologies (including ICTs) to support forms of relational coordination.

In another research direction, Latour's (1987) actor-network theory (ANT) combines the broad-scale thinking of the SST tradition with new conceptualizations that raise technologies (such as computers and communication networks) to a status equal to that of human actors (Lamb and Kling, 2001). This perspective explores the intricate interrelationships between people and the technologies they use to interact with other individuals, organizations and institutions within complex, interconnected networks (Walsham, 1999).

4. EXTENSIONS OF FORMAL MODELS FOR HANDLING SOCIAL ASPECTS

The concepts of Graph Theory seem to have an enormous potential in modeling social aspects of collaborative networks, as a natural framework for representing relationships, interactions and collaboration. This framework is supported by a

graphical representation of entities and relationships, and enhances the understanding and sharing of network relationships, supporting network management methods and algorithms.

Although sometimes not in a straightforward way, complex and non tangible factors crucial in the set-up and management of collaborative networks can also be modeled by this type of framework.

There are a lot of commercially available network optimization tools; packages for supporting network design; and software for drawing several types of networks. These tools are used for modeling interactions and quantitative relationships, but they have in general a very limited capacity to represent non tangible, qualitative relationships (such as the level of trust or the exchange of tacit information), and to deal with multiple criteria in evaluating different operating alternatives.

Although Graph Theory has been extensively used in other domains for a long time, there are few practical applications in supply chains, in enterprise networks or in virtual organizations.

As a natural extension of more traditional models, we may assign all sorts of attributes (numerical, textual, ...) to the entities or nodes of the graph, in order to model competences (skills or "capabilities"), "values" or importances, physical location, "trust level", "history", ... Similarly, edges may be assigned distances, capacities, costs, logistic means, ...

Then, by using traditional algorithms, more complex measures such as the "connection capital", "centrality", "groupability", can be calculated from the graph, if appropriate values are assigned to the connections.

In collaborative networks, when tackling with social aspects, multi-criteria assessment of alternatives is in general required, leading to the need of establishing trade-offs in selecting alternatives. For example, in selecting a business partner, say e.g. a supplier, these trade-offs might involve trust, reliability, price, delivery conditions, etc. In such situations there is no "best alternative" and in order to capture the trade-off idea, we need to consider non-dominance of alternatives and involve human decision-makers in the actual process of selecting alternatives.

The social aspects of new collaboration forms create the need for extending the theory to deal with new issues such as soft non-quantitative relationships, dynamics, trade-offs between individual and common objectives. The approaches traditionally used in the field of Multiple Criteria Decision Making, by explicitly dealing with multiple perspectives, may therefore give interesting contributions to the models of Graph Theory.

On another line, SSM - Soft Systems Methodology and other "soft" problem structuring approaches from OR can provide interesting contributions for enriching Graph Theory models, as these models will in principle be able to easily encompass the "soft" aspects portrayed e.g. by "rich pictures" and other semi-informal graphic representations. I.e. values and attributes can be defined to represent non quantitative issues identified through those methods.

Moreover in order to better capture non tangible and qualitative aspects of reality, Fuzzy Set Theory and Fuzzy Logic could probably be, at least partially, incorporated into the above approaches, thus creating more powerful analysis and design tools.

5. TECHNOLOGICAL CONSEQUENCES

It is now clear that rigid relationships (hierarchies) and functional dependencies, based on the traditional approaches, are not appropriate to manage the complexity of today's webs of relationships in business networks and do not fulfill their growing requirements. The need to freely handle quite different management issues such as operations, collaboration, negotiation, plans, etc., calls for new systems concepts and new information technology models, far from the simple client/server architecture.

Intelligent agents technology, peer-to-peer and grid computing are emerging in the business community as promising business information systems platforms. Nevertheless, a real breakthrough has not yet taken place, probably because new management concepts can only emerge in a complex interaction with new information systems concepts.

In business networks, management information systems should be based on three fundamental ideas: networked collaboration support, networked decision support and networked knowledge management. This requires multi-perspective (inter) enterprise models, including knowledge models and decision-making models, able to support and enhance management activities both for individuals and for groups. These models are inherently distributed, and thus agent technology, peer-to-peer and grid computing naturally fit into their implementation requirements.

Through a "multi-perspective model" managed by a computer, persons and groups should be able to fully explore webs of relationships that are important in their scope of operation and responsibility. We should be able to analyze, "design" and manage at different levels and from several perspectives, linking the network of social actors in a hyper-web of relationships.

A new reference architecture for management information systems should be able to cope with two characteristics of future collaborative networks: heterogeneity and complexity. Therefore, highly flexible information technology infra-structures are needed. Intelligent agents, peer-to-peer and grid computing are promising technologies to answer these requirements. Agent based architectures provide a platform for the integration of heterogeneous services such as order distribution support in logistics management or skill capital optimization in human resources management. Software agents and in particular intelligent agents technology provide both the way to implement flexible and sophisticated business functionality and the way to encapsulate the existing (legacy) systems in a way that reflects the networked nature of holistic forms of management. Peer-to-peer and grid computing will in the near future provide a much more flexible and powerful way of processing management data at several levels than current data warehouse bases architectures.

6. SOME APPLIED RESEARCH DIRECTIONS

In general terms, we might say there is a need to combine "hard social theory" with "soft engineering modeling approaches". Social modeling of collaborative networks should rely on sound social theory and not on superficial general statements as often found in the literature.

The "engineering" of collaborative networked organizations must deal both with technical and organizational issues (including social, cultural, political, economic aspects), and for that purpose relevant organizational issues must be adequately represented. Social theories try to describe and/or explain the behavior of the social world. Nevertheless, most of the "engineering" views of organizational aspects in collaborative networked organizations are based on outdated social theories (e.g., general systems theory, scientific management). There is therefore a need to incorporate more recent perspectives on the social world into engineering approaches and, as referred above, research should be organised around three main general topics: networked collaboration support; networked decision support and networked knowledge management.

Balancing social and engineering approaches

On the other hand, effective theoretical and practical innovation can only be achieved if these theories are wisely combined with engineering, operational research and computer science approaches and methods. Social theories such as structuration theory, social actors networks, actor-network theory, organizational semiotics are already being used for research in the areas of information systems, social informatics, requirements engineering, and even for modeling enterprise networks.

Examples of research topics in this direction are:

- *Methodological Frameworks* - approaches to integrate results from the different fields such as Social Actor Networks, Graph Theory, Multiple Criteria Decision Making, Soft Systems Methodology, Fuzzy Set Theory and Fuzzy Logic;
- *Holistic Business Process Engineering and Management* - approaches to analyze, model, design and manage collaborative business processes including explicitly social, organizational and economic aspects.

Network-centric research

Many of the above referred ideas and approaches can also be applied in the exploitation of new concepts for management, especially for networks of small and medium enterprises. For example, recently Scares and Sousa (2003) have proposed a new structural approach (hyper-management) for supporting the modeling of a collaborative network by considering two key concepts: social networking and hypertext. Here social networking refers to a range of approaches both from sociology and organization theory (as seen before), where the organization and their members are viewed as nodes in networks. Hypertext is a concept that underpins today's forms of interaction in the Internet and information technology in general. Based on these ideas, hyper-management arises as a unifying concept, aiming at considering both the local and the global, the detailed and the aggregate, the technical and the social, the structure and the behavior.

The management of an enterprise, or a network of enterprises, can in fact be viewed as the management of relationships and interactions between the different actors, directly and indirectly involved in the activities. Relationships involve operations, processes, resources, knowledge, social interaction, trust, power, etc. Relationships can be related to other relationships. For example, an operational relationship between a procurement manager and one of its suppliers is related (is

influenced) by his relationship with the other suppliers, by the relationship of the supplier with other clients, etc.

This idea can be considered an evolution of the concept of meta-management (Moschowitz, 1997) in virtual organizations, going from the management of distributed tasks linked to some previously agreed overall goals, to the management of a web of relationships also linked to individual goals and expectations.

The way an actor (i.e. any node in a network) moves from one subject or activity to another strongly depends on the relationships he actually perceives and on his goals and objectives at each given moment. Therefore, there can be several levels of relationships. For example, depending on the level of aggregation considered, we can explore the relationships between companies, between teams, between roles, etc.

A holistic management view also requires managing the relationships and interactions of individuals and groups with technology, by adequately positioning the technological artifacts (e.g. software agents in information systems) into the social context of human action. In fact, today, information technology and systems have a so strong influence in human actors' relationships that it is interesting and useful to conceptualize them as social actors on their own.

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THE ORGANIZATIONAL SEMIOTICS NORMATIVE PARADIGM

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Creating and using collaborative information system models that are not only technologically adequate but are also acceptable by the human communities that are supposed to use them is an important research issue. Our approach is based on the organizational semiotics stance, with an emphasis on semantics, pragmatics and social aspects, combined with a multi-agent system perspective. Our goal is to provide a better theoretical support for collaborative networks, going beyond the ad-hoc application of advanced information technologies. In particular, we propose an approach, based on organizational semiotics social concepts, and formalized using deontic agency logic, for representing and using shared knowledge, including beliefs, behaviour and values. Finally we point out some research challenges and propose a research agenda within the main knowledge areas identified.

1. INTRODUCTION

Information technologies have been going through an exponential growth during the last decades and the plateau of the usual S-shaped curve is still not on sight. Yet, information systems analysis and design is stagnant as an academic discipline. It seems to be a sub-area of software engineering, that exists only to facilitate the application of computers, but the number of systems that fail due to system requirements inadequacy is overwhelming. Estimates vary around 40-50% of computer-based projects failure rate (Stamper 2000). They fail not for technical reasons but because the systems do not adequately serve the organization.

Information systems analysis and design problems translate into a challenging agenda of research, especially if one considers that the problem is compounded when we go from the organizational level to the network level, where multiple organizations collaborate to perform a task or to achieve some goal(s).

Here, we introduce a stance that is not common in information technology and information systems research, namely the organizational semiotics approach (Stamper 1996). Semiotics, *the science of signs*, was formally described by Peirce more that a hundred years ago, although the publication of his works was made much later (Peirce 1931-1958). The semiotics stance, as we shall see in section 2, is particularly useful for describing information and communication systems, such as organizations, going beyond technology and encompassing a social perspective.

An important methodological component of organizational semiotics is *norm analysis,* since organizations are fundamentally normative information systems. Norms provide both the description and prescription of models of organized

behavior. Norms describe ideal behaviors, which in social terms may be translated into sets of obligations.

Since we are concerned with organizational information systems, which are social systems, we have adopted agency theory to help us create social models of the reality of organizational structures, which we postulate to be made of sets of agents, whose nature can be individual or collective and who, by definition, can be human or artificial entities with choice control, i.e. they encapsulate their decision mechanisms.

Below we propose agency deontic logic, an agentive form of the *logic of obligations,* as an adequate formalism for representing social norms. An important aspect of norms that differentiates them from simple rules is that norms can be broken, This is necessary to accommodate the autonomous nature of agents.

An information system that is analyzed and developed using these notions uses or provides:

- A better understanding of the underlying social phenomena,
- Better human action support than hard objectivist approaches,
- Adequate requirements analysis and system specification, in the scope of the software engineering process,
- Larger perspective, explaining the normative essence of organizations as both faces of the same coin (social / individual).

The main research challenges involved in this approach are related to theory development and system implementation, namely:

- Improvement of social agent models and organizational semiotics,
- Development of applications based on deontic agency logic representations. The problem is that unlike first-order logic, both deontic logic and agency logic use logic operators on well-formed formulas, to compose new well-formed formulas, which makes both of these logics higher-order logics, with the inherent computational complexity problems.

2. SEMIOTICS

2.1 General

Semiotics is the science of signs. One of the concerns of semiotics is precisely to say whether and how we use signs to refer to something. However, there is another question that is: what induces us to produce signs?

The first researcher who made this question the very foundation of his theory – semiotic, cognitive and metaphysical – was Peirce (see his collected works: 1931-1958). Peirce advocates the activity principle as foundational: he suggested that the recognition of things in the world is made by a process that he designated as semiosis. This process is actually an interpretation process by which someone creates in his mind a representation of some object in the world.

2.2 Semiosis

The classical definition of a sign "aliquid stat pro aliquo" was modified by Peirce, who expanded it into "*a sign is something which stands to somebody for something in some respect or capacity"*. Peirce's definition emphasizes that a sign has at least

three aspects: Some physical representation, something to which this refers or alludes and somebody able to interpret this relationship and form a concept. A concept, as much a percept (see below), is a mental notion that is formed in an interpreter's mind. These elements constitute what is usually called the representational triangle, as shown in figure 1.

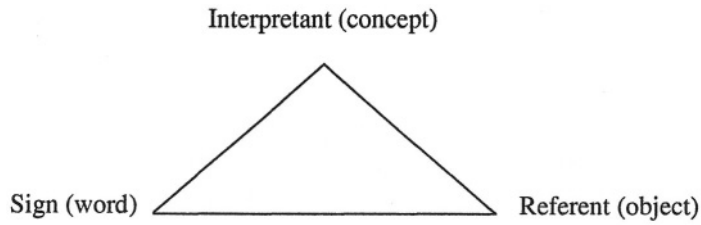

Figure 1 - Peirce's representational triangle

2.3 Extended Semiotics Classification

The main dimensions of Semiotics have been identified by Morris (1946) as Syntax, Semantics and Pragmatics. However, to encompass both a social perspective, and a physical perspective of sign, Stamper (1996) introduced the so-called semiotic ladder, adding another three levels to the previous three.

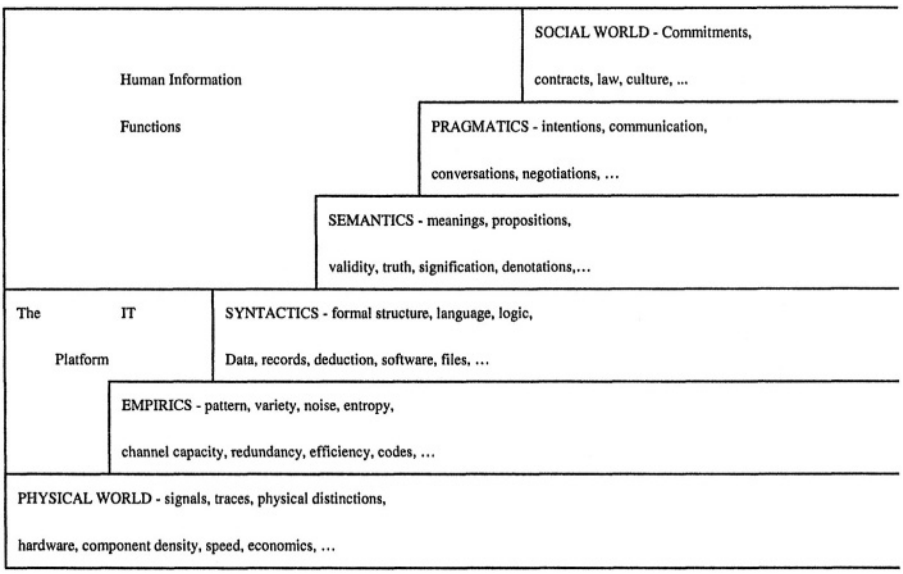

Figure 2 – The Semiotic Ladder (from Stamper, 1996)

The lower levels can be automated, i.e. can be implemented by machines, whereas the upper levels require human control. Yet, there is opportunity for using information technology support in many tasks usually assigned to humans, being worth mentioning the case of intelligent multi-agent systems.

2.3.1 Physical Level

This level is concerned with the economics of information. Signs are modelled by physical signals (varying in time) and marks (static in time), their sources and destinations and the routes over which they are transmitted. Information is a collection of physical tokens. Successful communication is achieved when a chain of physical tokens, transmitted along a route, is received at the other end, by the receiver, conserving the same physical properties.

2.3.2 Empirical Level

This level is concerned with statistical properties of information. Signals and marks are modeled by stochastic processes and probability distributions. The main interest of empirics is to analyze their statistical properties. Information is defined as the entropy of a source S: $H(S) = -\Sigma\, p_i \log(p_i)$, which measures the unpredictability of an information source. Successful communication at this level is achieved when the receiver can reconstitute the same sequence of symbols that were sent by the sender, irrespective of any problems at the physical level. Research at this level involves the study of communication devices that are well matched to the statistical characteristics of the media, maximizing signal to error rates, and the study of special codes that enable error detection and error correction.

2.3.3 Syntactical Level

Here, signs correspond to logical tokens that stand for some physical token or tokens that are often called symbols. Syntax is concerned with the analysis and generation of symbolic structures by manipulation of symbols using production rules. Concepts such as complexity, ambiguity and structural richness are objects of research at the syntax level. One of the most useful syntactic concepts is the generative mechanism called theorem proving, by which symbolic expressions (formulae) are mapped into others, according to a set of rules (axioms). This is also called deduction. In the syntax level the concept of information is such that it is possible to say that two sets of formulae convey the same information if each can be deduced from one another. Communication at syntactic level presumes the existence of devices able to process symbolic expressions. Communication is successful if the devices are able to identify and internally rebuild each other's symbols and expressions, irrespective of the symbols that are used. Symbols in one device are mapped into a set of isomorphic symbols in the other device, not necessarily the same set.

2.3.4 Semantic Level

Semantics is concerned with the meaning of signs. However, different philosophical stances differ in their definition of meaning.

If an objectivist view of the world is adopted then it is adequate to postulate that symbols and well-formed formulae, defined at the syntax level, are mapped into the 'real' world. This mapping constitutes a 'meaning function' thus providing a mathematical account of meaning.

However, in a social environment, where consensus is not guaranteed, it is possible that different agents have different views of the world. In this case it may be necessary to negotiate and unify the individual mapping functions or even to negotiate and complete one or more of the individual views of the world with missing concepts or relations.

The constructivist meaning semantic principle is essential in most aspects of business organizations, because people interaction always requires semantic unification of the concepts exchanged through speech acts.

At the semantics level communication is successful if the representational triangles are equivalent in both the speaker and the hearer, according to an operational procedure reflecting one of the semantic principles. If an utterance may be interpreted in several different ways this means that the interpretation selected by the speaker would be the same one selected by the hearer.

2.3.5 Pragmatical Level

Pragmatics is the level of semiotics concerned with the relationship between signs and the potential behavior of responsible agents, in a social context. Intentions have a very important role at the pragmatics level. A meaningful utterance is a sign supposed to carry some intention assigned to it by the speaker and interpreted and acted upon by the hearer. Even not acting may be an action if it reflects the response of the hearer to the speaker's intention. In speech act theory intentions are modeled in terms of the illocutionary properties of the speech.

Pragmatics relates intentions to behaviors. Therefore, successful communication at this level is achieved if the hearer understands the speaker's intentions, irrespective of the syntactical correctness and semantic accuracy of the interpretation of the communicative act. The communication may be successful even if the hearer does not do what the speaker wishes him to do, as long as the hearer correctly interprets the intention expressed by the speaker.

2.3.6 Social Level

Typically, communicative acts have perlocutionary effects, which correspond to the creation of attitudes prior to the actions performed by the hearer as a result of its interpretation of the communicative act. These actions may create, sustain, or alter social relationships, being therefore the actual social consequences of sign communication.

Communication at the social level requires the hearer and the speaker to share social norms. There are several different kinds of norms, which determine the way a social member sees the world. One particular kind, relevant for the current line of reasoning, is behavioral norms: These norms are rules that not only constrain individual behavior but also guide individual behavior according to the society interest, defining what could be called social goals. Within each society member, social goals and individual goals are weighted, reflecting individual preferences according to its axiological system, which may vary in time. Constraints and goals, social and individual, may be conflicting, therefore it is usually necessary that the hearer reason about the possible results of its actions and decide accordingly to its preferences.

A communication act at this level is considered successful if some perlocutionary effects on the hearer's side are achieved as a response to the intention transmitted by the speaker, which change the social world. Even if the hearer does not do apparently anything, the communication succeeds at the social level as long as a result of the communicative act, any social commitments are created or modified.

Meaning, at the social level, refers to the relations of signs to the norm structures specific to the social context where the sign is uttered. Such a sign is meaningful if it actually alters those norm structures. Knowledge at the social level is thus essentially defined in terms of norms, *i.e.* regularities of behavior, perception, judgment and belief.

3. INFORMATION FIELDS AND ORGANIZATIONS

The information field paradigm is inspired by a physical analogy: clusters of social norms define normative fields, just like electromagnetic forces define electro-magnetic fields.

The adoption of the information field paradigm provides a new way to look at information systems, revealing:

- Firstly, that information systems are normative social systems. Information systems have existed since human beings were able to use signs for communicating with each other.
- Secondly, that information systems are not to be confused with the media that support them: for example, the invention of writing has permitted new ways to deliver information and to improve the efficacy of pre-historic information systems, as much as the computer has improved the efficacy of contemporary information systems. Furthermore technology has enabled us to explore new types of information and to modify the structure of current information systems, but technology should serve human information systems. As Stamper (1996) argues: '*Only by correctly embedding the computer system in the human social system can the data it contains have any meaning, express knowledge or support intelligent behavior*'.
- Thirdly, that the unifying concept across all the layers of the organizational structure is the concept of norm. Fields of norms are shared by organizational agents and govern their behavior.

3.1 Norm-Based Organizational Models

Organizations have a structure: people get things done in an organized way in so far as their behavior exhibits regularities. However, organized behavior may or may not involve explicitly declared formal rules. Organized behavior without written rules, based upon informal co-ordination, is actually the characteristic of an organizational structure that is classified by Mintzberg (1979) as a "simple structure" that is present in all organizations, especially in the smallest, where this may actually be the only information system available.

When the size of the organization increases, decision processes face cognitive overloads, or the operations become too complex (*e.g.* requiring co-ordination between several specialized people), organizations typically become what Mintzberg defines as a 'bureaucratic machine' – requiring a 'formal information system'. By

formalizing tasks and communication between people a large organization becomes more efficient.

One of the advantages of bureaucracy is that routine information tasks may be performed mechanically, by people who do not understand the precise meaning or purpose of the signs they are handling. This deskilling has been the basis for automation. IT has found its application field mainly in the automation of all kinds of repetitive semiotic tasks for which it was possible to find an algorithm. This is what is denoted by Stamper as the 'technical information system' (three lower semiotic levels in figure 1).

3.2 Semantic Analysis

The result of the semantic analysis of the domain of interest, or universe of discourse, consists of the definition of all the Nuclear Contents / Cognitive Types of interest and their relationships. This may also be designated as the domain ontology. However it is worth noting that the word ontology is used here in a different sense than in the artificial intelligence field. Here, we use the traditional meaning that refers to the area of philosophy that studies the *Being,* and in that spirit *ontology* is a description of the entities that exist in the domain of discourse and their relationships, with an emphasis on how the existence of each thing depends on the existence of others. This concept of *ontological dependency* introduces a structure into the ontological assumptions that is largely absent from the classical ontologies.

3.3 Ontology Charts

The "ontology chart" (Stamper 1996) is a diagrammatic description of a core component of the semantics of the domain of interest, based on the *agents* that populate that domain and the perceived and socially constructed *affordances,* i.e. types of behavior related to roles or agent capabilities.

Ontology charts emphasize ontological dependencies between affordances. For example, an agent *A* who is an employee (*affordance*), can go on to experience some other kinds of behavior such as being fired. This dependency of the existence of one kind of behavior upon another is what is called *ontological dependency* and is captured in ontology charts.

Figure 3 shows an example of an ontology chart, which depicts an organizational framework, in the Polytechnic Institute of Setúbal, related to book acquisitions. In this diagram we have followed the conventions below (those in squared brackets are optional):

The essential advantage of ontology charts over, for example, Entity-Relationship (ER) models lies on the fact that *ontological dependencies* shown only on ontology charts are less prone to change than entity relationships. Ontology charts provide a way to establish the semantics of very stable relationships in an organizational environment. In the forefront of work on this issue is Ades (1999) who applied Semantic Normal Form (SNF) for representing ontological relationships and assessed the stability of software systems, using real cases, when requirements were obtained based on ontology charts.

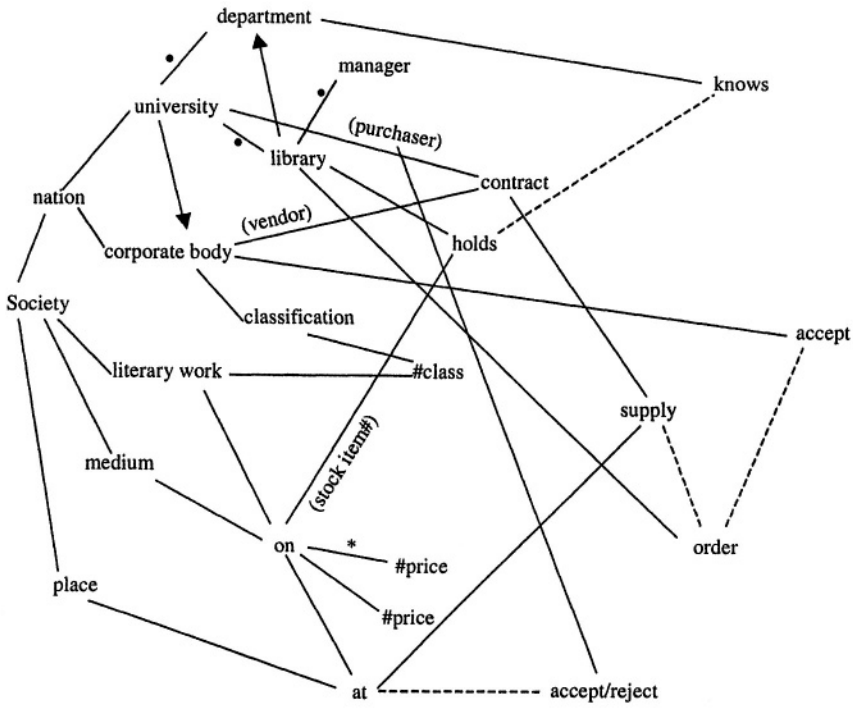

Figure 3 – Ontology Chart

3.4 Norms

The information field paradigm is based upon the concept of *norm* as a unifying device across the multi-layered organizational onion. There are different kinds of norms, all reflecting a different kind of regularity that enables a social system to share different aspects of social life, such as perceptions, meaning interpretations or behavior. This paradigm may be used to help understand and create formal models of communities of practice, proposed by Wenger (1998).

Norms are typically social/individual phenomena, in the sense that they are created by societies, although this process involves individual society members, and they are intended to maximize the common good but individuals use them to minimize cognitive overload.

Norms involve multi-agent entities (organizations / networks). Therefore, they are an essential aspect of any organizational information system. Norms are multi-agent objects: Individual agents generate norms and use norms as heuristic knowledge to improve individual behaviour; Society maintains and enforces norms in defence of the common good.

Social psychology provides a well-known classification of norms, partitioning them into perceptual, evaluative, cognitive and behavioural norms. These four types of norms are associated with four distinct attitudes, respectively:

- Ontological – to acknowledge the existence of something,

- Epistemic - to adopt a degree of belief or disbelief,
- Deontic - to be disposed to act in some way,
- Axiological - to be disposed in favour or against something in value terms.

A norm can be formalized as a well-formed formula with the following structure:

<wff norm> ::= <agent-term> [<role-term>] <action-term>

where the <agent-term> defines the responsibility assignment, <role-term> defined the type of norm and the <action term> defines the item of knowledge or object of discourse.

This ontology ties every item of knowledge to an agent who, in a sense, is responsible for it. From here follows a set of assumptions that correspond to a radical subjectivist philosophical perspective:

- Instead of an objective truth, there is a concept of truth that corresponds to the set of agents' beliefs.
- Agents are responsible for the consequences of the beliefs they choose to adopt (epistemic)
- Agents are responsible for their behaviour (deontic)
- Agents are responsible for their values (axiomatic)

3.5 Formal Representation of Norms

The branch of Logic that deals with norms and normative reasoning is Deontic Logic (the logic of obligations). This logic incorporates a special higher-order operator *O* (the *ought* operator). Related operators, *F* (forbidden) and *P* (permitted), are derived from the first one $(F\varphi \equiv O\neg\varphi$ and $P\varphi \equiv \neg F\varphi)$.

The first viable system of deontic logic was presented by von Wright (1951):

(OS1) $O\varphi \equiv \neg P\neg\varphi$ **(having an obligation** φ **is equivalent to not being permitted not** φ **)**

(OS2) $P\varphi \vee P\neg\varphi$ **(either** φ is **permitted or not** φ **is)**

(OS3) $P(\varphi \vee \psi) \equiv P\varphi \vee P\psi$ **(permission to** φ **or** ψ **is equivalent to being permitted** φ **or being permitted** ψ **)**

(OS4) $(\varphi \equiv \psi) \vdash (P\varphi \equiv P\psi)$ **(if two assertions are equivalent then permission to one implies permission to the other and vice-versa)**

Since then, many other deontic logic axiomatic systems have been proposed, all of them suffering from the existence of paradoxes: from a set of wffs is produced a conclusion that is contradictory with one of the initial wffs. The solution for this problem with deontic logic requires connecting deontic logic with agency logic, i.e. it requires adopting a radical subjectivist perspective to define the deontic-agency wff as

<D.A. wff norm> ::= O**[<agent-term> [<role-term>]** ***stir.*** **<action-term>]**

where O is the deontic operator and ***stit*** (see to it that) is the agency operator. The complement of the deontic operator is always an agentive sentence. When this is the

case, it can be demonstrated that the paradoxes that plague deontic logic cease to be a problem.

Using this methodology it seems to be possible to define organizational roles and their relationships, either to create an internal model of a particular organization or to create a role-based model of a network of collaborating organizations. This capacity has not yet been extensively explored in information systems development and seems to be a promising area of research, especially for interdisciplinary teams who are able to combine technological capacity with social understanding.

4. SUMMARY

The development of information systems requires not only technological sophistication but also the understanding of the application environment and, especially, the system users' ontology. We have shown that *information* is a very complex concept, requiring several levels of analysis. The semiotics stance uses, as basic building block, the concept of sign and concentrates on the meanings of signs, the purposes for which they are used and the social consequences they produce: identified in the semiotics ladder as the semantics, pragmatics and social levels. Given this stance, it is possible to understand organizations as normative systems where shared meaning is generated in a constructivist way, defining what are called information fields. The information field concept seems to provide a particularly useful paradigm, opening up a number of theoretical and practical research questions. Norms regulate the organizational agents' activities and are the ontological basis of information fields, where agents are role-playing entities and roles are described as sets of norms.

5. A RESEARCH AGENDA

As a science, collaborative information systems have plenty of challenging problems to solve (Stamper 2000). For example:

- ensuring for the people who use information that it is meaningful,
- making explicit the intentions behind the messages they handle,
- making explicit responsibility assignments for the messages and information handled in the system,
- formally represent the social effects that information produces, or must produce if it has any value at all, such as shared understanding, mutual commitments, acceptance of common goals, etc.

The organizational semiotics approach outlined in this paper is new in many ways. Although the promises of the approach are many, as indicated below, much more remains to be made both at theoretical and technological level in order to improve what has already been done and to make it more practical. Each of the topics below represents a research avenue:

- Organizational semiotics focuses on the concept of sign as a basis for more complex concepts such as *information,* and in the process it offers a theory that can be used to understand and optimize information systems that work on practical human organizations. This theory needs further development.
- Semiotics is based on a constructivist paradigm, where shared meaning is negotiated among shareholders; methodologies and tools need to be improved in order to facilitate shared knowledge acquisition and representation,
- The social perspective described in the paper, enables the formal representation, creation and management of commitments, based on a collaborative perspective of individuals in a society that facilitates the achievement of individual objectives in an environment of global stability. Commitment management, including legal enforcement, and trust are notions crucial for virtual organizations, based for example on intelligent multi-agent information systems. One application of these concepts could be e-commerce.
- The normative perspective defines information spaces, where collaborating individuals share a number of norms of different types: epistemic, deontic and axiologic. These types of norms, well known in social psychology, can be incorporated in organizational information systems, being of particular interest for collaborative networks. This normative structure, found in human societies, can be implemented in organizational information systems in order to facilitate system adoption by the users.
- The information field paradigm makes possible to represent dynamic environments where coalitions are formed and terminated according to the objectives of individuals and the advantages of their collaboration. This dynamic morphology of networks may be well suited to representing many modern highly adaptive organizational structures.
- Semantic analysis, by means of ontology charts, is a way to formally represent shared meanings across stakeholders, thus improving the adequacy of information systems to the organization. An interesting technical improvement would be the transformation of the current graphical notation into a logical notation, thus enabling automation of some of the reasoning that can be done based on these shared meanings. This would also entail the challenge of handling deontic logic and other modal logics, which suffer from high complexity computational problems.
- Pragmatic analysis, i.e. the identification of the agent intentions behind the actions of the organizational agents, is particularly important in conversation analysis and patterns of interaction for coordination. Much work has been done in this area, since Winograd and Flores (1986) defined some conversation patterns, by Dietz, Weigand, Goldkhul, and others. This is an important research area, which is being pursued also by organizations such as OMG (Object Management Group) and FIPA (Federation for Intelligent Physical Agents), aiming at developing adequate standards.

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AN EXAMPLE ROADMAP

A ROADMAPPING METHODOLOGY FOR STRATEGIC RESEARCH ON VO

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Roadmapping is nowadays recognized as an important strategic planning tool to forecast both the critical development needs and the steps required to reach major advances in an area; and thus provides a valuable tool for decision-making. However, in spite of the growing interest in roadmapping and some existing successful examples, especially for the manufacturing area, the roadmapping Is always performed by a group of specialists in that area, and unfortunately there is no real systematic roadmapping "approach" or even visioning "methodology" so far defined. This chapter presents an attempt in this direction, and provides a ten-step approach towards such a methodology for visioning and roadmapping.

1. INTRODUCTION

Roadmapping became quite popular in the USA in late 1990's, and more recently in Europe, especially in terms of technology roadmaps, as an approach to strategic planning for the future of technology in different sectors. The main benefit of technology roadmapping is that it provides information to make better investment decisions by identifying the critical technologies and technology gaps, as well as identifying the ways to leverage R&D investments for opening new frontiers in the areas. However, a common definition for roadmapping or developing a "roadmap" does not exist. Furthermore, the observation of roadmaps that have been so far created indicates that there is considerable diversity among practitioners as to what constitutes a roadmap and the roadmapping techniques employed. According to some authors, roadmapping is just *good planning* [5]. For Robert Galvin in [8]:

> "A 'roadmap' is an extended look at the future of a chosen field of inquiry composed from the collective knowledge and imagination of the brightest drivers of change in that field."

Another definition from Vähäniitty, et al. [15]:

> "Roadmapping is a popular metaphor for planning and portraying the use of scientific and technological resources, elements and their structural relationships over a period of time. The process of roadmapping identifies, evaluates and selects strategic alternatives that can be used to achieve desired objectives, and the resulting roadmaps summarise and communicate the results of key business decisions".

From most definitions provided so far, it can be derived that a roadmap shall reflect the knowledge/vision of a group of visionaries and experts, and not necessarily the widest democratic consensus. In fact, the term "reaching consensus", so popular in many European funded roadmapping research circles, can be even dangerous and counter productive, if taken to an extreme, for the development of a roadmap, aiming to open new frontiers. Real breakthroughs in science and technology are always the result of activities of a few visionaries, not something created by a "parliamentary decision" or "poll". And hence, the value of roadmapping and visioning for future, must be assessed by the soundness of its arguments and approach, as well as the logic applied to its steps, and not only by the number of votes it has collected or the consensus that it has reached. In other words, the assessment of a roadmap is something that can only be done by those visionary experts with a quite broad view and understanding of the target area.

For roadmapping, a variety of categories, with rather different target, scope, and level of generality, can be considered. For instance, the following are addressed in different literature [8], [9]:

- Science and research roadmaps
- Industry roadmaps
- Cross-industry roadmaps
- Technology roadmaps
- Product roadmaps
- Product-technology roadmaps
- Project and issues roadmaps.

The IST VOmap roadmapping project was designed as an extension of the IST THINKcreative project, aiming at identification and characterization of the key research challenges needed to fulfill the vision, the required constituency, and the implementation model for a comprehensive European initiative to promote and implant dynamic virtual organizations (VO) [14]. The VOmap is clearly positioned at the science and research roadmap level, among the categories addressed above. Therefore, unlike the most usual type of roadmappings performed and documented so far, clearly the achieved result of VOmap is not a roadmap focused on a particular product or technology, rather the definition of a strategic research program in the area of virtual organizations.

A first step of the work in the VOmap project focused on the investigation of existing roadmaps. A good number of roadmaps are now publicly available (see [1], [2], [3], [4], [5], [6], [7], [11] for instance). However, in spite of the growing interest in roadmapping and a few attempts to structure the corresponding process [10], [16], there is not yet a real systematic roadmapping approach or even a visioning methodology defined. Even for one of the main well known steps, the "gap analysis step", there is no clear procedure or set of tools available to be applied. Also, the known approaches, such as the "SWOT analysis", do not directly apply here and cannot help, due to the following two facts:

1. Existing approaches are not "procedural" methodologies that can be simply applied to this case, and
2. The target context of SWOT analysis is typically very different than what is needed to be generated for visioning and roadmapping, which is in fact an ordered set of transition steps and a time line for reaching the desired vision of future, based on both the existing status and the foreseeable advances.

Furthermore, most roadmap studies performed so far have followed a long-term procedure (longer than one year), led by a group of experts (called roadmap leading team or coordinators), and involving a very large group of experts from industry, research, and academia (typically more than 100).
Therefore, although looking for inspiration from a large number of roadmap examples, the VOmap project, with the duration of one year and constituting seven partners, had to develop its own innovative working methodology and procedures for roadmapping, which is summarized and exemplified in the next sections.

2. STEPS TOWARDS A ROADMAP

At a macroscopic level, a roadmap consists of three main components: (1) the characterization of the current state of the art that makes the baseline, (2) the vision or the desired "future", and (3) a structured set of actions to achieve the vision. Figure 1 below represents the goal of the VOmap in a nutshell, which is to develop a Roadmap, identifying at the end all necessary transition steps, including the research, development and implementation stages, to reach the future desired state of the Virtual Organizations.

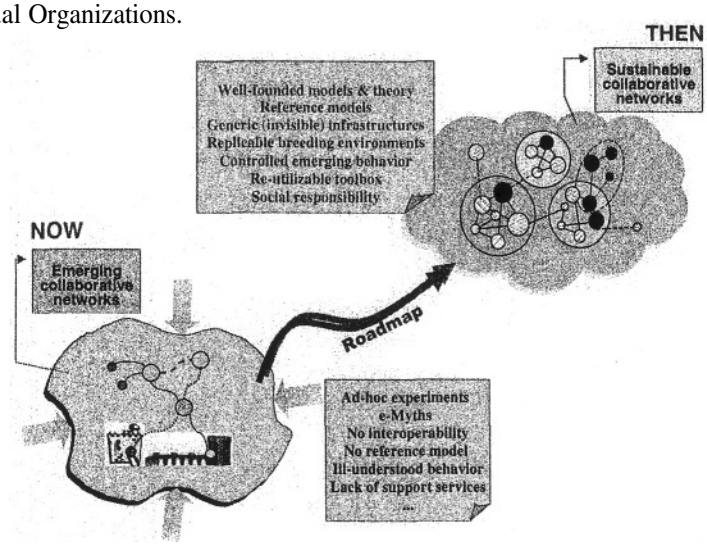

Figure 1 - VOmap in a nutshell

Considering the current state of collaborative networks and virtual organizations in Europe, in order to elaborate a list of actions that will likely help achieving the desired vision, the following steps or tasks were proposed and defined for the VOmap roadmapping methodology. Although this step-wise methodology was defined during and for the VOmap roadmapping, the defined methodology is generic enough, such that its current steps or with some minor modifications, can be applied to roadmapping in other areas:

STEP 1. Characterize and consolidate the baseline

By characterizing the state of the art in virtual organizations, both in terms of

research and practical experiences, and trying to integrate and consolidate available results from a large number of other projects in the area of VOs, this step will establish the baseline, i.e. the departing point for the roadmap exercise.

In the case of VOmap, a large number of sources were used, including: the results of the IST VOSTER project that analyzed a portfolio of more than 30 research projects on VOs [13], the VOmap partners' experience resulted from their participation in a large number of European and other national/international VO related projects, the IST THINKcreative project findings, and other related surveys and roadmaps.

STEP 2. Perceive trends and design scenarios

Further to the baseline, it is important to perceive major trends and analyze plausible future scenarios that can be envisioned from those trends.

Fig. 2 below illustrates how these first steps were developed in the VOmap and some of their corresponding results labeled as R1, R2, etc.

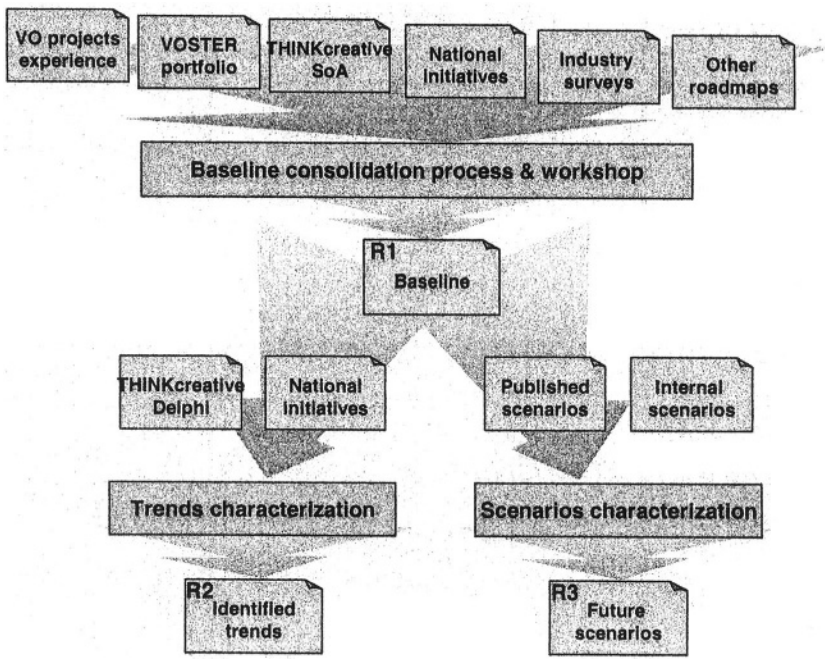

Figure 2 – VO baseline, trends and scenarios

STEP 3. Elaborate first vision statement and instantiations

Vision building is not a mechanism to foresee the future. Clearly, the entire future of the collaborative networks and VOs can never be fully predicted. However significant market trends, technology trends, the state of the art, and the consolidated baselines resulting from the previous steps can be used as resources, mechanisms,

and/or constraints, towards *establishing a vision for desired collaborative networks of the future.*

At this point it is important to distinguish between the scenario planning and definition of a vision. In comparison to scenarios, that provide the foreseen future cases, a vision represents a *desired future,* which implies at its heart a "pro-active attitude" and therefore the need to plan actions to reach that desired future state. As such, scenarios of the future VOs provide a part of the input required for the analysis of the developed vision.

Figure 3 below represents our view of the interrelationships among the trends, the scenarios, state-of-the-art, and the developed vision.

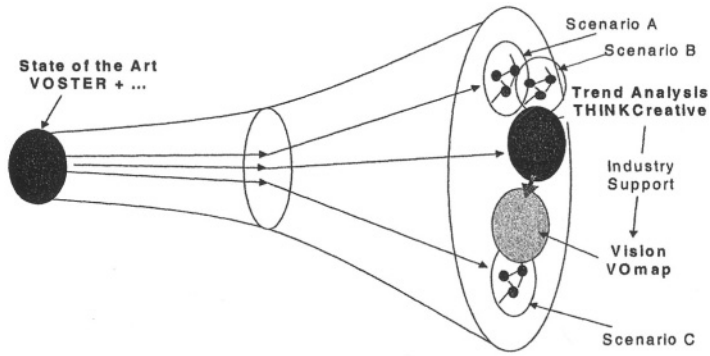

Figure 3 – Vision versus trends and scenarios

A typical vision statement is a generic expression of the desired future state. In many cases it makes sense to then further detail the generic vision according to different perspectives or facets. In the VOmap case an important contribution, which results from understanding of the VO paradigm as a multi-disciplinary one, was the "instantiation" of the vision according to five specific focus areas (Fig. 4) consisting of: Socio-economic, VO management, ICT infrastructure, Support services, and Formal models and theories.

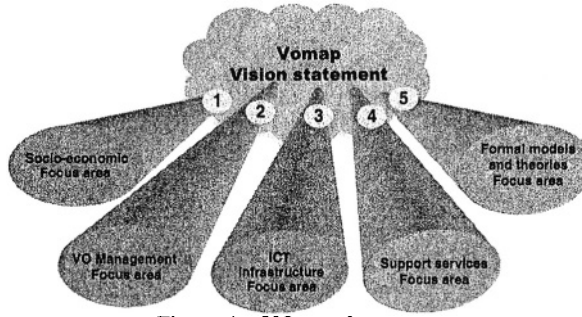

Figure 4 – VOmap focus areas

Furthermore, the initial vision statement and its instantiations developed in this step, shall be repeatedly validated and refined by a large group of experts from academia, research, and a variety of industry sectors, during the following steps of the proposed roadmapping methodology.

Figure 5 shows the main activities performed in the VOmap visioning step. Chapter 7.2 presents the results of VOmap's 1st vision of its instantiations to the five focus areas, also a partial example of visioning results can be seen in Figure 9.

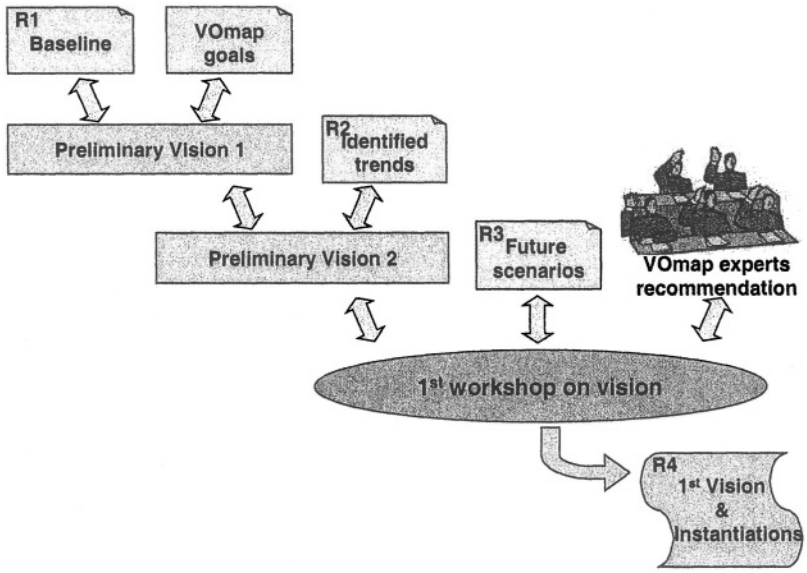

Figure 5 – Visioning step

STEP 4. Fill the GAP: Where we are – to – Where we wish to go

Identifying the gap between the current baseline and the desired vision is the next important step. Putting the baseline and the vision statement side by side will allow the experts to make a "visual" comparison and therefore identify the gaps.

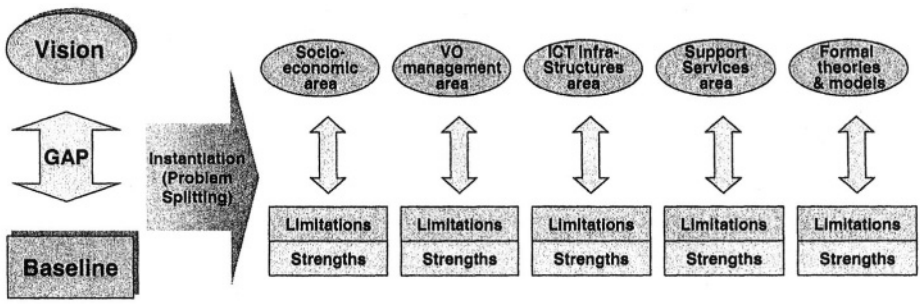

Figure 6 – Vision and baseline instantiations for gap analysis

According to the VOmap approach, for gap analysis, the detailed characterization and essence of the baseline ("where we are") in comparison to the vision (where we wish to go) is achieved by two main facets of the current states: the Strengths and the Limitations (Fig. 6). And again, similar to the vision, this baseline characterization and gap analysis shall also be divided and approached (instantiated) according to the specificities of each of the main focus areas.

After reaching the gap analysis instantiations, we can generate the "Influence maps" (presented as either matrix or graph, Fig. 7 and Fig. 8 respectively), to represent the positive / negative influences of the baseline towards the achievement of the vision.

A "strength" is likely to have a positive effect (rated further as moderate or high) on some of the vision facets. A "limitation" on the other hand will have a negative influence (rated as moderate or high) on the achievement of some of the vision facets.

These influence maps provide some qualitative analysis of the state of potentials and barriers on the road to reach the vision. Therefore, these maps will help experts to observe how difficult or easy it is to achieve a vision facet.

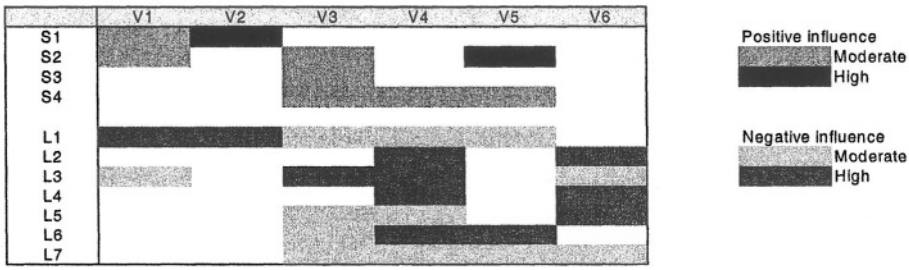

Figure 7 – Example of influence map – matrix form

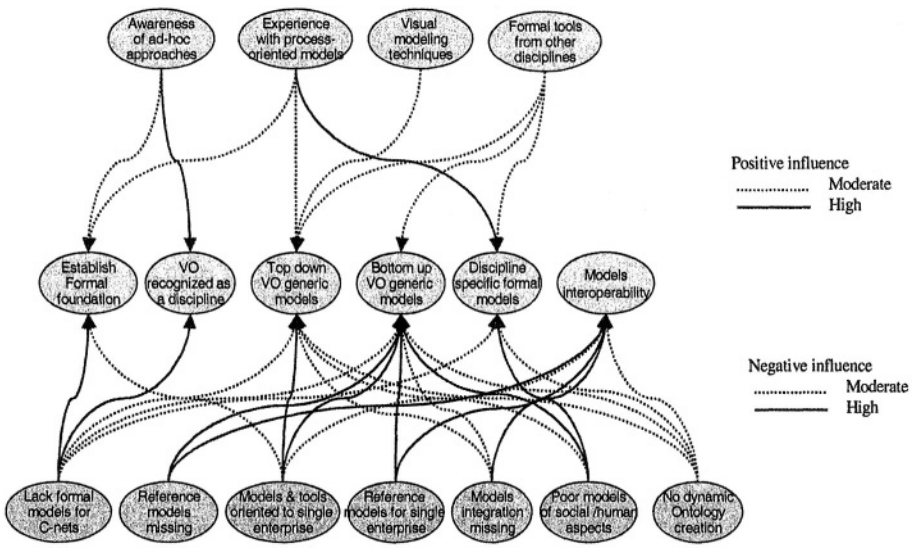

Figure 8 – Example of influence map – graph form

STEP 5. Propose a plan of actions (a first set of unordered transition steps)

Due to its complexity, here we do not need to necessarily suggest "one" procedure on how this step can be achieved. Several different ways could be pursued. For instance, using all the results achieved in previous steps, an expert in the field may pursue his/her systematic (difficult to devise) or "ad-hoc" approach to configure and propose these actions. Or even a group of experts may brainstorm on producing

some plan of actions, which is in fact what can for instance be achieved in a workshop of experts. Therefore, no matter how it is done, a list of actions (un-ordered transition steps) must be designed for each main focus area. An example set of results is shown in Fig. 9 for the focus area of formal models and theories.

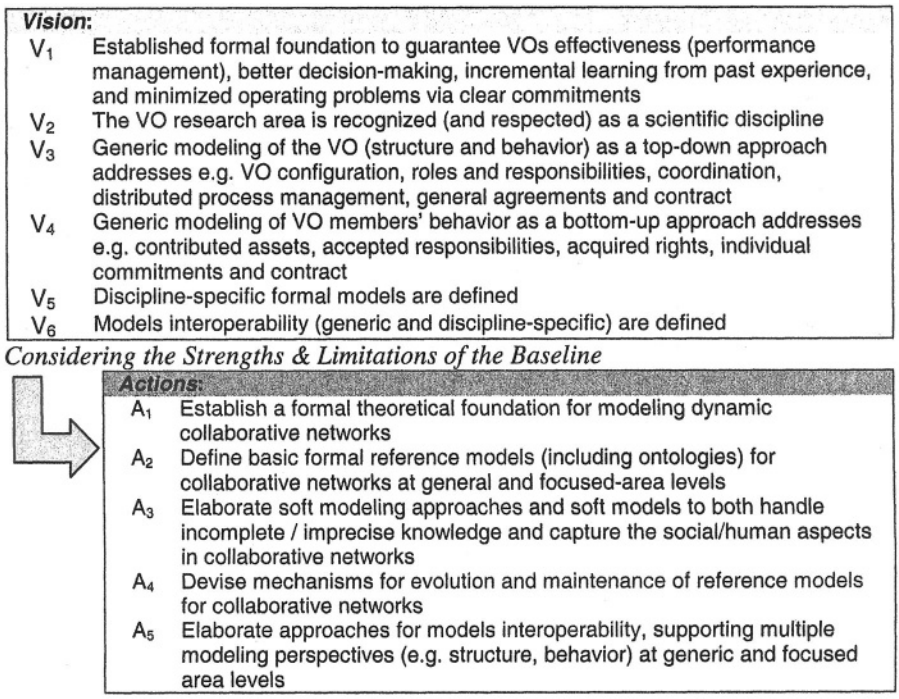
Vision:
V1 Established formal foundation to guarantee VOs effectiveness (performance management), better decision-making, incremental learning from past experience, and minimized operating problems via clear commitments
V2 The VO research area is recognized (and respected) as a scientific discipline
V3 Generic modeling of the VO (structure and behavior) as a top-down approach addresses e.g. VO configuration, roles and responsibilities, coordination, distributed process management, general agreements and contract
V4 Generic modeling of VO members' behavior as a bottom-up approach addresses e.g. contributed assets, accepted responsibilities, acquired rights, individual commitments and contract
V5 Discipline-specific formal models are defined
V6 Models interoperability (generic and discipline-specific) are defined
Considering the Strengths & Limitations of the Baseline
Actions:
A1 Establish a formal theoretical foundation for modeling dynamic collaborative networks
A2 Define basic formal reference models (including ontologies) for collaborative networks at general and focused-area levels
A3 Elaborate soft modeling approaches and soft models to both handle incomplete / imprecise knowledge and capture the social/human aspects in collaborative networks
A4 Devise mechanisms for evolution and maintenance of reference models for collaborative networks
A5 Elaborate approaches for models interoperability, supporting multiple modeling perspectives (e.g. structure, behavior) at generic and focused area levels

Figure 9 – First proposition of research actions for formal models and theories

STEP 6. Verify the planned actions

Since the approach taken in Step 5 is most likely an ad-hoc approach, in order to validate the proposed set of actions, here in this step we consider to apply two main verifications means on them, as specified by the criteria below:

Criterion 1- Check how the proposed actions "contribute" to the fulfillment of the vision.

Criterion 2- Check how "feasible" these actions are, considering the two facets characterizing the baseline, i.e. the positive and negative factors.

In both cases we also like to come up with some "qualitative values".

In each focus area, the results of Criterion 1 constitute several many to many relationships between the Actions and the Vision statements. Namely, based on the coverage, it would indicate for each action, the exact vision statement that it influences, and vice versa. At the same time, we also rate the qualitative level of this relevance or coverage for each Action, as Moderate, High, or Very High.

On the other hand, criterion 2 would result the feasibility check of the Actions against the 2 facets (positive and negative) of the baseline, and this time rated by the qualitative level of their difficulty, as Moderate, Hard, Very Hard.

The result of Step 6 on the example case presented in Figure 8, is shown in Figures 10-12.

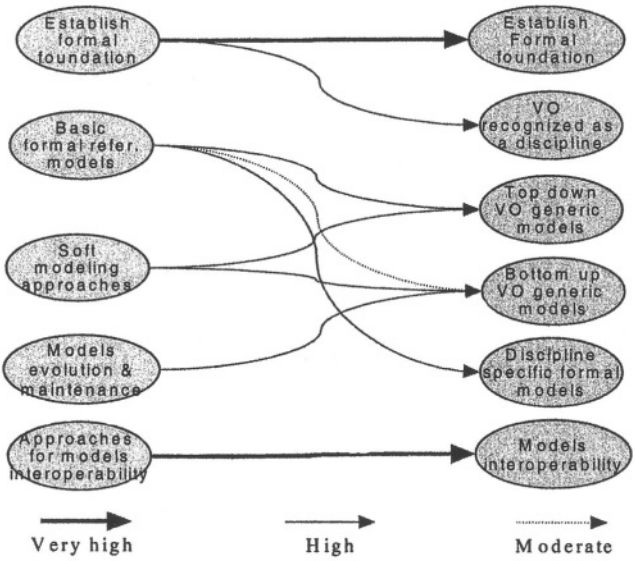

Figure 10 – Example of contributions and feasibility of proposed actions – graph form

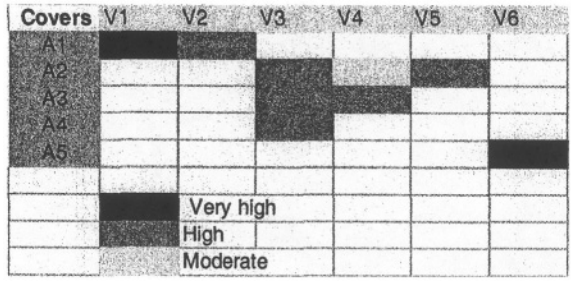

Figure 11 – Example of contributions and feasibility of proposed actions – matrix form

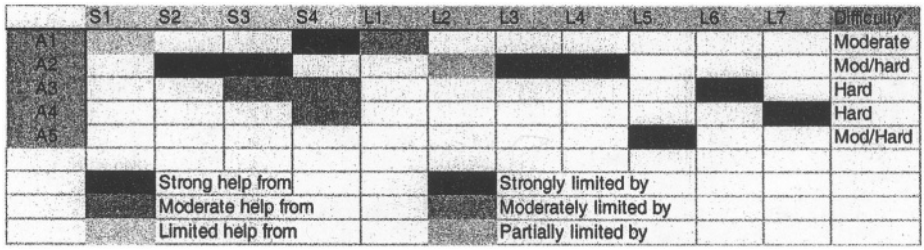

Figure 12 – Actions feasibility check for the formal theories and models focus area

Clearly these verification results may require changes in the planned actions to fulfill the vision, and hence Steps 5 and 6 will repeat until all vision statements are properly supported by the planned actions.

STEP 7. Plan the timing and other characterization of actions

Here we try to identify the importance and introducing the time plan, in order to better characterize those actions generated in Step 5 and verified in Step 6, by adding the main relevant features such as time, resources, required skills, etc.

STEP 8. Finalize the definition of the roadmap chart

Here, taking the results of Step 7 above on the actions, we check the inter-dependencies among the actions and produce the time-based transition steps for each focus area, as well as among different focus areas. As such:

FIRST: This task focuses on the careful identification of the interdependencies and links among different actions within each focus area, by also paying careful attention to the time schedule of these actions. Here a partial roadmap chart will be achieved for each focus area, by the generation of a chart, representing an ordered set of transition steps and the time line for these steps.

SECOND: These partial roadmap charts will be inter-related, by careful consideration of how the transition steps in one focus area will relate to those of the other focus area.

In this inter-linking / harmonization exercise among all 5 focus areas, sometimes the logical order and/or the time order among different transition steps (from different focus areas), necessitates a change in the partial roadmap chart for the focus areas, that are generated before. For instance, in the simple example of Figure 13, the transition step A3 (from Focus Area A) needs the results of the transition step B2 (from Focus Area B). Therefore a change is required in the plans for one of the two focus areas, in order to make these two focus areas harmonized, i.e. either A3 must move forward in time (e.g. locate below A4) or B2 must move backward in time (e.g. locate above B1) in order to guarantee this inter-linking.

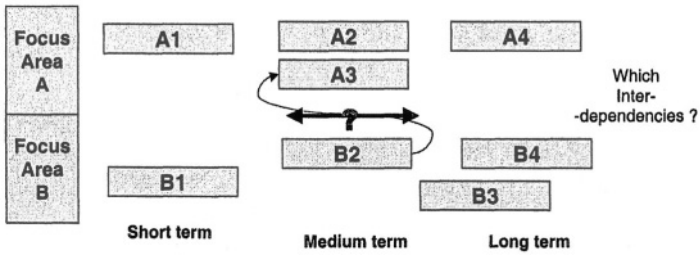

Figure 13 – Roadmap presentation template

At the end of this Step, a first roadmap can be developed and summarized in a diagram as shown in Fig. 14.

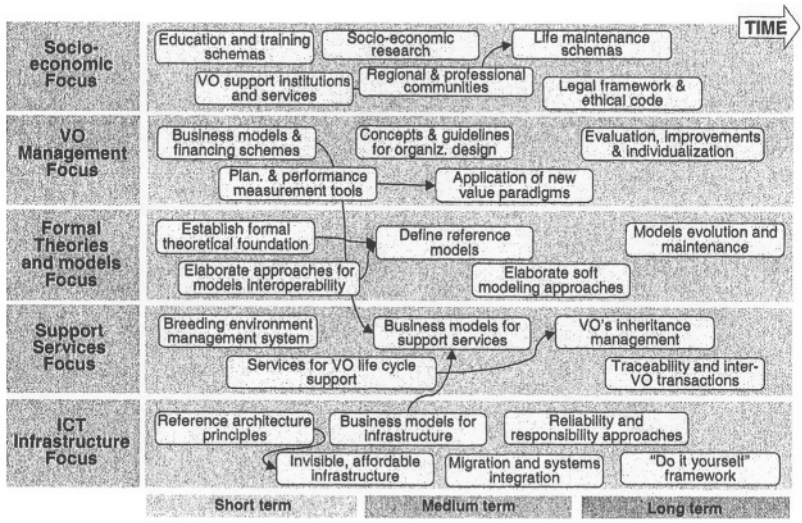

Figure 14 – The first draft roadmap

STEP 9. Perform consultation and refinement

After the elaboration of a first draft roadmap, it is important to validate and refine it further, with the participation of a wider group of experts. For this purpose, VOmap has established a Support Group of more than 40 organizations from the various European regions. A key mechanism to get a strong involvement of this Support Group was the organization of a number of **regional meetings / discussion panels,** which took place in several countries including: Portugal, Netherlands, Germany (2), Switzerland, and Finland (2). It shall be noted that SMEs, although the potential major beneficiaries of the VOmap strategic goals, have difficulties in getting involved as full partners in a roadmap design process, mainly due to the involved "bureaucracy" of this type of initiatives. Nevertheless, many SMEs are quite willing to get committed to participate in discussions and interaction with other experts about the VOs. The regional / local meetings proved to be a very effective mechanism to get the participation of SMEs that usually are not available to attend large meetings abroad. With this distributed consultation mechanism a total of 100 experts, 45% from enterprises, 45% from academia, and 10% from other organizations could take part in this process, that otherwise could not get actively involved in this roadmap design. Complementarily, a number of other well-known experts from non-European countries including: Australia, Japan, Brazil, Mexico and Canada, were also invited to review the roadmap results via email and suggest improvements.

Unlike other roadmapping approaches that try to perform all steps of the process through workshops involving a large number of participants, the VOmap approach first resorted to its many sources of input used by its core members (small number) to elaborate a draft roadmap and only then submitted it to a refinement process via the regional workshops. This approach proved to be very effective under the time

and resources constraints of this project. All workshops were quite focused and the feedback received from participants was very positive.

As the last activity in this step, the integration and refinement of the roadmap was performed, generating the 2nd draft roadmap (Fig. 15), taking into account the results of the regional workshops. This was done within the Integration Workshop participated by the core members.

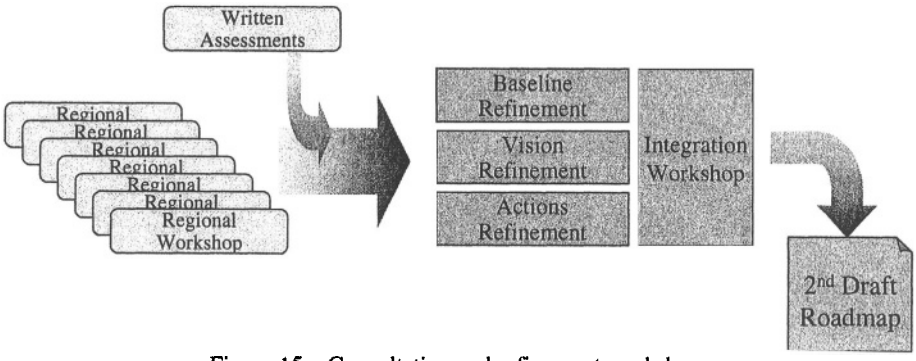

Figure 15 – Consultation and refinement workshops

In addition to the discussion of the draft roadmap, important elements for the regional workshops are the structured collection of feedback regarding the various components of the roadmap. One such mechanism is a voting procedure to capture participants' opinion about the vision statement and the proposed research actions.

In the case of VOmap results, the participants of all regional workshops were also invited to vote on the relevance of the vision statement and its instantiations according to a 5-level scale (from "little relevant" to "very relevant"), as the final collective results for this voting is illustrated in Fig. 16. For this purpose, for voting on the proposed research actions, each participant was given a total of 10 votes and asked to select the ten most relevant actions among the proposed total of 27 actions, with the constraint that at least one action from each focus area should be selected.

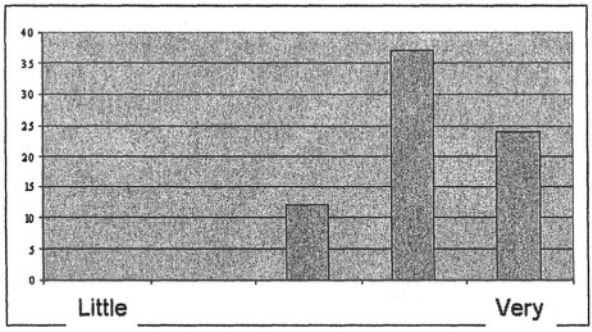

Figure 16 – Voting example from regional workshops – relevance of the vision statement

STEP 10. Perform consolidation

The last step involves the roadmap implementation planning and estimation of

necessary resources (Fig. 17).

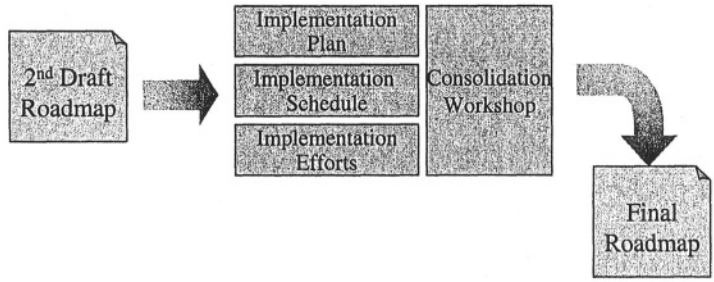

Figure 17 – Implementation planning and consolidation

In the case of VOmap this was done through a final consolidation workshop involving all the core members as well as the expert participants of the regional workshops.

Three implementation mechanisms were considered in this step (Fig. 18.a), including: the R&D activities, the Trials, and the Broad deployment and improvement. Clearly, rather than being strictly sequential, these mechanisms may in fact overlap along the time, but with different emphasis at different times (Fig. 18.b).

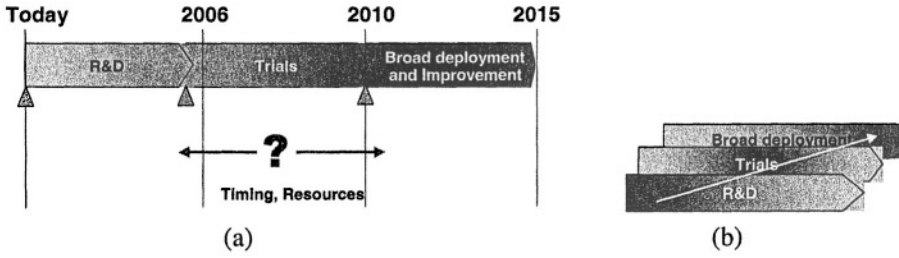

Figure 18 – Implementation mechanisms

Chapter 7.2 also represents the final results of the VOmap roadmap generated in Step 10 of this methodology.

4. CONCLUSIONS

The IST VOmap project has developed an effective roadmapping methodology and has proposed a strategic research roadmap for virtual organizations of the future, focused on creating the necessary strong foundations and mechanisms for establishing an advanced collaborative and network-based industry society in Europe.

The proposed methodology, although not a very rigorous *algorithmic* solution for roadmapping, introduces some structure for this difficult process, what proved quite effective in the case of a roadmapping exercise under severe time and resources constraints.

Finally it is important to notice that roadmapping is not a process that ends at the Step 10 of this methodology, rather for roadmapping, it is fundamental to proceed with periodic revisions of the "vision and roadmap" through out its implementation phase. Since the needs / initial motivation, the surrounding environment, and major drivers are evolving, it is necessary to review and update the vision and planned research steps and actions proposed in the roadmap. The periodic revisions will tune the vision and roadmap by applying the changes in their input parameters.

Acknowledgements. The authors thank the VOmap partners – Uninova, VTT, University of Amsterdam, FhG IAO, Virtuelle Fabrik, CeTIM, and CAS - for their contribution to the design of the roadmapping methodology.

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A STRATEGIC ROADMAP FOR ADVANCED VIRTUAL ORGANIZATIONS

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A roadmap for the necessary integrated research and technological developments towards a new generation of virtual organizations is presented. This roadmap was developed in the context of the 1ST VOmap project and it covers five specific focus areas of: Socio-economic, VO management, ICT infrastructure, Support Services, and Formal models and theories. The vision designed for the roadmap, the proposed actions to reach the vision, as well as the schedule and suggested efforts for each action are presented in detail.

1. INTRODUCTION

Emerging "networked age" fundamentally changes the way that commercial, industrial, cultural and social activities are organized. In this context, Europe has already invested in a considerable number of research projects applying new organizational forms, which have produced an abundant variety of specific solutions and broad awareness for necessary organizational changes. However, most support for European research has been highly fragmented in more than fifty projects in the area of Virtual Organizations (VO), where each one is focused on solving specific problems and applying IT to partially design and develop a minimal B2B interaction mechanism to support their basic needs. As such, there is no effective consolidation/harmonization among them in order to have an impact at the European level. On the other hand proliferation of fast changing short-life non-interoperable technologies is a major obstacle for small and medium size enterprises (SMEs) entering collaborative partnerships.

This chapter presents a roadmap developed in the IST VOmap project [1] that aims at identifying and characterizing the key **research challenges** needed to **fulfill the vision**, required **constituency**, and the **implementation model** for a comprehensive European initiative on dynamic **collaborative virtual organizations** (VO). The VOmap **vision** is that of an effective transformation of the landscape of European industry into a **society of collaborative relationships**. In order to be

efficient and competitive in their operation, VOs of the future have to rely on solid bases and strong methodological approaches. The approach of VOmap is to support cohesive business ecosystems to leverage both the potential of the European diversity, and the innovative potential of the emerging "network culture" and human-oriented VOs.

Furthermore VOmap builds on preliminary results from two other IST networks, the THINKcreative and VOSTER projects. THINKcreative aims at the identification and characterization of emerging organizational collaborative forms and their required infrastructures, modeling and application tools, as well as the corresponding socio-organizational needs for the next 5, 10 and 20 years [12]. The VOSTER project represents an effort to cluster major European VO projects, systematize the state of the art, and contribute to the harmonization of models and infrastructures [13]. Chapter 7.1 provided a 10-step methodology introduced in the VOmap for roadmapping and visioning. This chapter mainly focuses on providing the results of the roadmapping process in the VOmap project.

2. VISION AND BASELINE

The baseline for virtual organizations in Europe can be summarized in the following statements:

- Research on VO has created a critical mass and European-wide *intuitive* understanding of the area.
- Basic supporting infrastructures and relevant technologies are well represented, but the developments are often focused on particular needs and based on ad-hoc experiments, hardly re-utilizable.
- Generic functions or harmonization of achievements are addressed only in a few projects.
- Efforts on general plug-and-play architecture and interoperability are also to a large extent missing.
  - Consequently, no generally accepted reference model or interoperability base are available.
- Although several disciplines are concerned, the main focus has been on the ICT infrastructure. Research on social/organizational, including management, is mainly focused on best practice. Integration with technological development and impacts on structures are not covered. In addition little research is focused on the social and organizational issues created by VOs

Furthermore, the rapid evolution of the Internet-related technologies and the fast proliferation of tools have facilitated the dissemination of myths and creation of expectations that are hardly confirmed in practice. There is, therefore, an urgent need to establish the foundations for a new research and development phase based on a clear strategic vision.

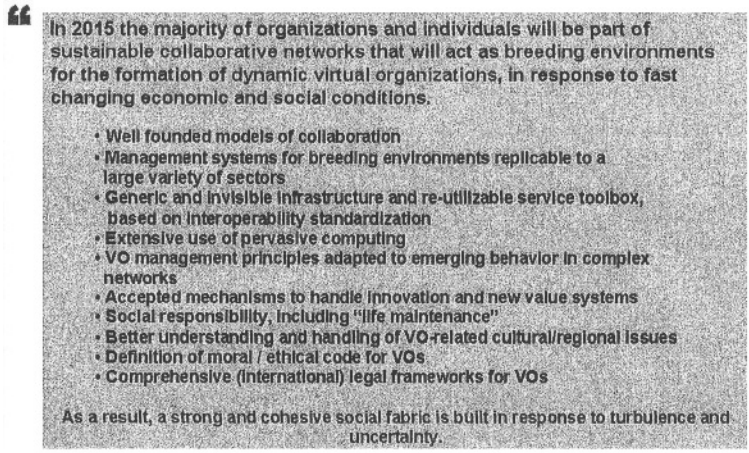
Building a vision for VOs is different than foreseeing the future or building future scenario cases. In fact, the entire future of collaborative networks and VOs in Europe can never be fully predicted. What is evident today and can be used for building the vision includes the significant market trends, technology trends, the state of the art, and the consolidated baselines. These together provide the resources,

mechanisms, and/or constraints, towards *establishing a vision for desired collaborative networks of the future.*

While scenarios provide the foreseen future cases, a vision defines a "*desired future*", implying the roles for many actors in the society, to assist reaching this desired future. Therefore, the visioning and roadmapping go hand in hand, with the first defining the target and the second defining the required actions, timeline, and efforts necessary to reach the target. As such, in fact scenarios of the future VOs provide a part of the input required for the analysis of the developed vision.

Therefore, although not a particular task in VOmap, the elaboration and characterization of plausible future scenarios for collaborative network organizations and professional virtual communities were carefully taken into account as necessary input for the visioning. The considered scenarios were either originated in different forums (e.g. THINKcreative, COVE, CE-NET) [12] and a few in the VOmap, or appeared in well-referenced and large international initiatives, backed by a huge number of experts' validation. Chapter 7.1 provides more information on the relation between the scenarios and the vision in the VOmap project.

The final general VOmap vision is presented below:


In 2015 the majority of organizations and individuals will be part of sustainable collaborative networks that will act as breeding environments for the formation of dynamic virtual organizations, in response to fast changing economic and social conditions.
• Well founded models of collaboration
• Management systems for breeding environments replicable to a large variety of sectors
• Generic and invisible infrastructure and re-utilizable service toolbox, based on interoperability standardization
• Extensive use of pervasive computing
• VO management principles adapted to emerging behavior in complex networks
• Accepted mechanisms to handle innovation and new value systems
• Social responsibility, including "life maintenance"
• Better understanding and handling of VO-related cultural/regional issues
• Definition of moral / ethical code for VOs
• Comprehensive (international) legal frameworks for VOs
As a result, a strong and cohesive social fabric is built in response to turbulence and uncertainty.

The above vision statement creates new opportunities for businesses, large and small, to become both more competitive in future global market and more innovative and risk taking. On the other hand it implicitly suggests the main areas needing attention from other social bodies and institutions in order to reach this desired state. Namely: 1) those areas in which the governments and regulatory bodies must invest more attention, and 2) those areas that require more research and development.

The purpose of VOmap and its roadmap is, therefore illustrated by Fig. 1.

Taking into account the multi-disciplinary nature and wide scope of virtual organizations, five main areas were considered to further focus and instantiate the development of the roadmap, including: (i) Socio-economic, (ii) VO management, (iii) Support services or application tools, (iv) ICT infrastructure, and (v) Formal models and theories.

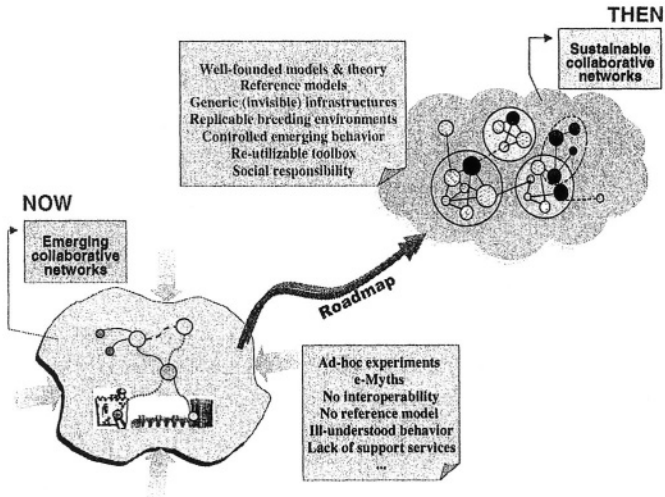


Figure 1 - VOmap in a nutshell

The general vision statement was therefore instantiated according to these focus areas. In addition to the instantiation, for each focus area the key facets or mechanisms that characterize the vision are further identified as shown in the next figures, forming the vision statements.

VOmap vision for the socio-economic focus area:

The socio-economic environment will be fully developed to support virtual organizations, stressing the importance of human-related issues at the individual and organizational level, in enabling institutions and in a transparent regulatory environment.	
Mechanisms:	
VE_1	People being prepared and supported to work as employees or professionals in enterprise networks or other virtual organization settings
VE_2	New mechanisms and professional communities to provide for human sense of belonging, long-lasting relationships and stability (social responsibility)
VE_3	New institutions and models to support "life maintenance", e.g. social security and personal training and development
VE_4	Support for companies by enabling institutions and services to set-up, enter and develop virtual organizations regionally and internationally
VE_5	Comprehensive and transparent legal framework, specially in the case of institutional collaboration
VE_6	Regional assets and cultural identity leveraged and preserved
VE_7	Well founded understanding of social and socio-economic processes and developments in the context of networked economies

VOmap vision for the VO management focus area:

Well-defined business models will be developed to allow the systematic VO management, namely to act in regards to planning, control, organization and leadership, taking into account the importance of social mechanisms in multi-interest collaboration networks, as well as the transitional nature of VO.	
Mechanisms:	
VM_1	Wide understanding of brokerage and pro-active approach to VO formation
VM_2	Understanding of strategy development and value creation in VO and the sub-sequent establishment of VO planning and performance assessment mechanisms
VM_3	Clear mechanisms for leadership and human resource practices, conflict management and participation with regard to shared and distributed decision-making in "multiple-objective" collaboration spaces

VM_4	Defined organization principles for seamless flow of responsibility, ownership, knowledge and benefits along the VO life cycle and across VO boundaries, in relation to customers, other networks and third parties
VM_5	Mechanisms and institutions to foster long / short term collaboration with the aid of "soft" trust-building support on internal and external level (e.g. code of ethics) as well as complementary "hard" incentive schemes

VOmap vision for the support services focus area:

IT support services will be developed to assist VO brokers, management and employees with their tasks for setting-up, operating and dissolving virtual organizations.
The tools are embedded in flexible architectures suited for different types of virtual organizations, driven by business, social, legal, etc. needs and are easy to use and provide a well balanced approach between human support and business process automation.

Mechanisms:

VS_1	Management of breeding environment (e.g. definition, behaviour, membership, rules, rights, responsibilities, business interoperability)
VS_2	VO creation framework (choices of automatic / semi-automatic or search assisted by the breeding environment's manager)
VS_3	Coordination/management of highly distributed activities (human assisted)
VS_4	Risk management, assessment tools, performance measuring and mechanisms for learning and experience collection
VS_5	Mechanisms for traceability and for handling post-cooperation IPRs and liabilities

VOmap vision for the ICT infrastructure focus area:

The ICT infrastructure will be developed as a transparent, low-cost, and easy to use enabler of collaborative behaviors in networked organizations.

Mechanisms:

VI_1	Technology-independent reference architecture for the horizontal infrastructure
VI_2	Provide support for federated information and resources management
VI_3	Flexible control mechanisms supporting the implementation of a large variety of behaviors
VI_4	Plug-and-play concept extended to inter-organizational services
VI_5	Full e-transaction security *and privacy* is guaranteed
VI_6	"Configure yourself" philosophy (user "programmable" infrastructure)

VOmap vision for the formal models and theories focus area:

Decision-making in all phases of the VO life cycle is based on well argued and verified models and methodologies, which are the basis for the ICT-based support for business and organizational development and operation, as well as the base for education, training, and active operation of VOs.

Mechanisms:

VF_1	Established formal foundation to guarantee VOs effectiveness (performance management), better decision-making, incremental learning from past experience, and minimized operating problems via clear commitments
VF_2	The VO research area is recognized (and respected) as a scientific discipline
VF_3	Generic modeling of the VO (structure and behavior) as a top-down approach addresses e.g. VO configuration, roles and responsibilities, coordination, distributed process management, general agreements and contract
VF_4	Generic modeling of VO members' behavior as a bottom-up approach addresses e.g. contributed assets, accepted responsibilities, acquired rights, individual commitments and contract
VF_5	Discipline-specific formal models are defined
VF_6	Models interoperability (generic and discipline-specific) are defined

Figure 2 – Vision instantiations

3. THE ROADMAP – PER FOCUS AREA

3.1 Socio-economic focus

This area addresses the societal environment and support mechanisms that are important elements outside the direct control of single (virtual) organizations or individuals. The actions required to support the vision for this focus area, target three different levels (Fig. 3):

- The individual who should be equipped with the skills and knowledge for working in a virtual organisation environment, and whose needs for social security, maintenance and belongings must be addressed
- The business network that should find suitable public infrastructures for working efficiently, especially in the regional context, but also being able to grow to an international or global reach level. Furthermore, the network needs to find a suitable legal and regulatory environment for its activities.
- The society as a whole that should be able to understand the developments potentially affecting everybody, and strengthen positive effects while reducing the negative ones.

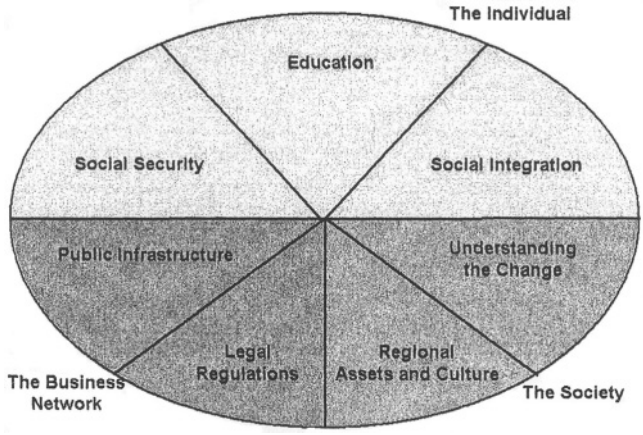


Figure 3 - Key elements of the socio-economic focus area

Based on these elements, the following strategic research actions are proposed from the socio-economic point of view, followed by the actions for the focus area and the distribution of efforts to reach its vision:

E1. Develop and establish education, training, and accreditation schemes for VO working on different professional levels. More and more job profiles will be influenced by the increasing adoption of virtual organization principles and set-ups. This can be the creation of new, specialized jobs such as network managers or coaches, or the inclusion of VO-related elements in traditional jobs such as project managers or sales representatives. This action is concerned with the development of an appropriate educational infrastructure including:

- Definition of appropriate job and qualification profiles for the different roles in virtual organisations

- Vocational and academic education schemes for specialised professions or as extension of current education schemes
- Training modules for qualification for new roles
- Accreditation schemes to make qualification comparable and support life-long learning and development.
- Roll-out and inclusion of these schemes in universities, colleges, or by private education providers.

E2. Elaborate and pilot regional and professional communities as "social homes" for people. Working and employment relationships are expected to become more fluent in a environment of virtual organizations. The more important it is to provide people with a more stable connection or environment that can help to overcome this insecurity. Regional or professional communities can cater for this need and make many additional services available such as a project agency, qualifications, social exchanges, etc. This action thus includes:

- The understanding of needs and requirements of professionals working in an VO environment
- The development of appropriate formats and services of professional communities for the "virtual age", but taking experiences of traditional communities such as engineering associations, trade clubs or Rotary/Lions clubs into account
- The piloting of different communities for gaining experiences and emergence of the most appropriate formats (supported as especially in the beginning, the communities might not have the critical mass for self-sustainability)

E3. Define life maintenance schemes and related business models with different stakeholders (providers, customers, public bodies). Current forms and regulations of life-maintenance schemes (pension schemes, health insurance, life-long education and development, etc.) still depend largely on traditional employment paradigms and do not take self-employment, project-based employment, and other forms typical for virtual organizations into account. This action intends to develop adapted forms and provision of life-maintenance. It includes:

- The analysis of societal development and change in working relationships in relation to the aspects of life-maintenance
- The definition of new requirement profiles and corresponding schemes and provision models with different stakeholders, such as employees needing support, private and public insurances, and national and European regulators)
- The development of corresponding policies and regulatory legislation
- The support and consulting along the policy and legislation making process.

E4. Develop institutions and services for VO support, and establish them regionally; network regional bodies and developments on European level. While the previous actions are primarily concerned with the individual level, these actions shifts the focus to the business network level. Currently, many

public institutions and service offerings are geared towards the individual organization. These include e.g. special consulting services, tax and custom handling, education centers to name but a few elements. The shift towards virtual organizations however requires new services (e.g. special finance consulting) a shift of services (e.g. special custom handling for international networks), or qualification of people (e.g. tax office, new modules in vocational training).

While the service offering and most institutions should maintain a regional focus for best customer service and safeguarding regional identity, it is required to support European exchange and qualification for synergies and removing any barriers.

This action intends to analyze the new and shifting requirements of business networks, pilot services and institutions in different regions and support the broad adoption on a European scale.

E5. Elaborate and implement comprehensive and transparent legal frameworks and ethical code at the company/VO and societal level. This main action can be split into two action streams, a company/network-oriented, and a national/European regulation-oriented stream.

The network-oriented stream encompasses especially:

- Elaborate legal templates and practices for different forms of virtual organisations within the current or future national and international legal environments for immediate practical use.
- Analyse potential areas of conflict and legal risks arising in operating virtual organisations and develop legal strategies to overcome them.

The regulation-oriented stream envisages:

- An analysis of key policy issues and implications in relation to different stakeholders, such as small and large companies, or the individual, different market areas, or different national institutional settings
- Development and suggestion of "policy packages" for supporting the development of virtual organisations, providing even playing fields, and overcoming regulatory hurdles
- Testing of these policies in theoretical and practical experiments, evaluation of effects after implementation
- Support and consulting of policy makers in the legislation process.

E6. Support integrated socio-economic research in networked economies. The societal change coming about through the virtualization of organizations is only beginning to show. Many developments and their consequences will not be obvious or easily discernible. It is therefore of great interest to the society and its members to support comprehensive socio-economic research in the different areas and aspects of networked economies. Potential topics could be:

- The change in work and life circumstances, social relationships, contentment of the individual
- Competitiveness, innovativeness, development and evolution of virtual organisations

- Competitiveness, openness and social developments in whole economies and societies.
- Most research topics require integrated and inter-disciplinary research approaches to understand the technical, business and social aspects of the developments.

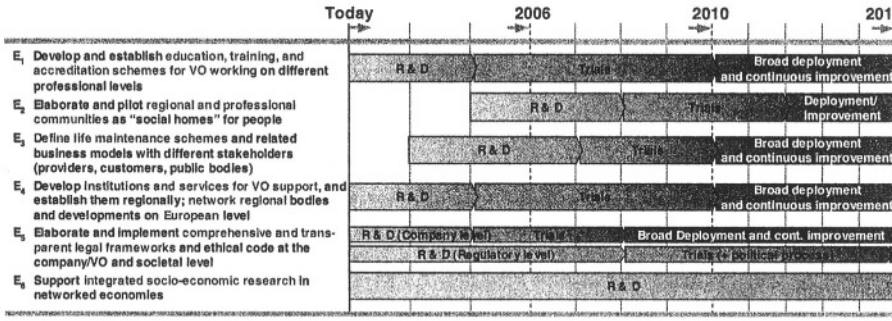

Today
2006
2010
2015
E1 Develop and establish education, training, and accreditation schemes for VO working on different professional levels
R & D
Trials
Broad deployment and continuous improvement
E2 Elaborate and pilot regional and professional communities as "social homes" for people
R & D
Trials
Deployment/ Improvement
E3 Define life maintenance schemes and related business models with different stakeholders (providers, customers, public bodies)
R & D
Trials
Broad deployment and continuous improvement
E4 Develop institutions and services for VO support, and establish them regionally; network regional bodies and developments on European level
R & D
Trials
Broad deployment and continuous improvement
E5 Elaborate and implement comprehensive and transparent legal frameworks and ethical code at the company/VO and societal level
R & D (Company level)
Trials
Broad Deployment and cont. improvement
R & D (Regulatory level)
Trials (+ political process)
E6 Support integrated socio-economic research in networked economies
R & D

Figure 4 -- Actions for the socio-economic focus area

Suggested distribution of efforts:

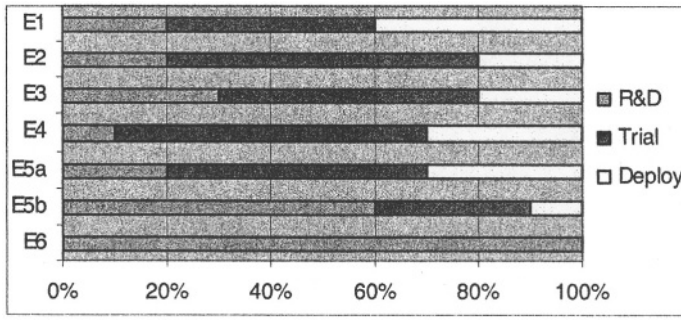


Figure 5 – Distribution of efforts for the socio-economic focus area

3.2 VO management focus

The VO management area addresses the critical issues that virtual organizations raise both for the managers of the VOs, as well as for the managers of single companies being engaged in virtual organizations. Decision-making in virtual organization context remains mainly a matter of human interaction; therefore the main goal of this focus area is to understand the particularities of management tasks in a networked environment. By investigating the requirements for the basic management tasks, such as planning, control, organizational design, and leadership, managers will be able to respond to the main new challenges. This focus area can be characterized by 5 key elements as represented in Fig. 6.

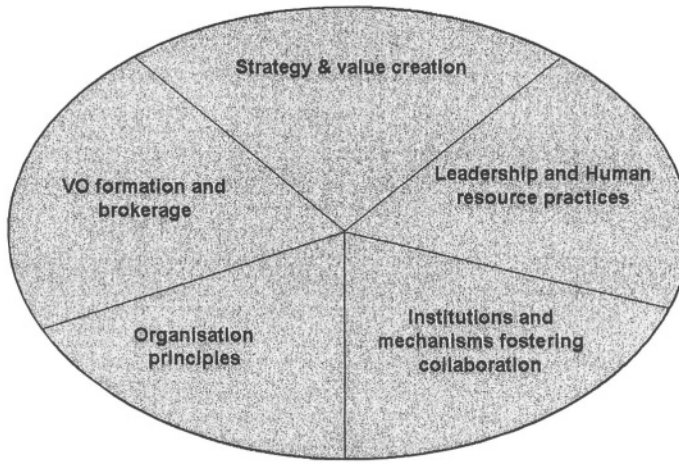

Strategy & value creation
VO formation and brokerage
Leadership and Human resource practices
Organisation principles
Institutions and mechanisms fostering collaboration

Figure 6 - Key elements of the VO management focus area

Based on these elements, the following strategic research actions are proposed from the VO management point of view, followed by the actions for the focus area and the distribution of efforts to reach its vision:

M1. Provision of business models and financing schemes for VO set up. Some researchers suggest that the whole VO concept as such represents a new business model for success, which is partly true, but there is still a lot of insight needed to avoid the failures of networks experienced in the past. Further research actions include:

- Exploration of advantages and success potentials of virtual organization with regard to value creation, especially the ability to provide additional and new value, ability to serve old markets better than traditional companies and explore new markets at lower risk, and ability to improve the transformation processes along the value chain.
- Definition of financing schemes for virtual organizations
  - Provide well-proven financing models for capital providers to explain what, when, why and how companies receive compensation for the product/services they deliver,
  - Provide models to create an integrated debt and equity structure, taking into account the individual company as well as the network's interests, and how monetary resources are used with regard to assets and liabilities, including the share of profits and losses.

M2. Provision of planning and performance measurement concepts and tools with regard to tangible and intangible assets. Even though there is a certain level of common consensus between partners in VO, the individual reasons for joining the VO are manifold and may interfere with the members' individual planning objectives. Planning processes within collaborative (and therefore more complex) structures are likely to differ from traditional top-down planning approaches and therefore need the following research actions:

- Exploration of planning and measurement processes in network contexts, such as

- the integration of different levels of planning and performance measurement (from the intra-enterprise entity up to the network level)
- the responsibilities and legitimacy of planning and measurement in loosely coupled entities
- modification of planning and measurement techniques to fit the transitional nature of the VO.

– Provision of planning and performance measurement models and contents suitable for networks, providing
- particular planning objects that are needed in virtual organizations, taking into account the dominant role of intangible assets in VO
- planning and measurement procedures that are commonly accepted and according agreement for corrective actions/sanctions
- a seamless integration into diverse organizational structures.

M3. Provision of concepts and practical guidelines for organizational design and implementation of VO. Only few of the pragmatic approaches to network design have been wrapped up in well-proven "off-the-shelf" network configurations that industry could put immediately into practice. Research actions include:

– Exploration of the nature of virtual organizing
- Identify new tasks and roles in virtual organizations and the boundaries of virtual organizing
- Identify the different organization layers (e.g. technology layer, process layer etc.) needed in virtual organizations, their interaction and implications for organizational design
- Identify well-proven organization rules regarding coordination mechanisms, division of tasks, share of responsibilities, design of organizational sub-entities (e.g. project teams) etc.

– Provision of "off-the-shelf" organizational design concepts that allow easy integration of partners along the value chain, with regard to
- organizational forms that support information exchange, continuous learning and entrepreneurship on the network level
- organizational forms that support leadership functions for geographically dispersed members.

– Provide guidelines for organizing intangible assets, especially with regard to knowledge workers (e.g. mixture of full-time and temporary employees, resolution of intellectual property issues etc.).

M4. Provision of methods for addressing critical "soft" issues (e.g. trust building) in VO collaboration. The concept of the VO differs significantly from the way business is done in these days and therefore represents an enormous challenge for the individuals involved. Further research by social sciences in the VO area is needed. Research actions include:

– Exploration of the nature of virtual work:
- Identify the changes and challenges in managing social relationships in a virtual contexts?
- Resolve the basic problems for human interaction in virtual environments with regard to emerging new roles and tasks for virtual workers, trust-building components stimulating interaction,

envisioning in a network context, preservation of individuality/identity vs. network interests.

- Provision of patterns of virtual work:
  - Guidelines for distributed negotiation and decision processes,
  - Network conflict resolution mechanisms,
  - Guidelines for the management of diversity, interaction schemes in communities.
- Identification of transition paths and learning requirements to ensure the transition from today's work practices into future virtual work.

M5. Ongoing evaluation, improvement and sector specific adoption of VO concepts. During the course of time and further experimentation with networks, some of the VO concepts will prove to be more successful in certain circumstances, while others are more appropriate for other environments. It is therefore necessary to evaluate the working practices in various industries from a holistic perspective, to extract the lessons learnt and put them at the disposal of companies in other industries that could benefit from these experiences. Research actions include:

- Consolidation of best practices from different industries
  - Extract critical success factors and identify well-proven methods for virtual enterprising and put them at the disposal of different industries
  - Provide institutions for virtual organization advice and consultancy
  - Based on the extraction of best practices, suggest and establish standards for VO management for multiple industries.

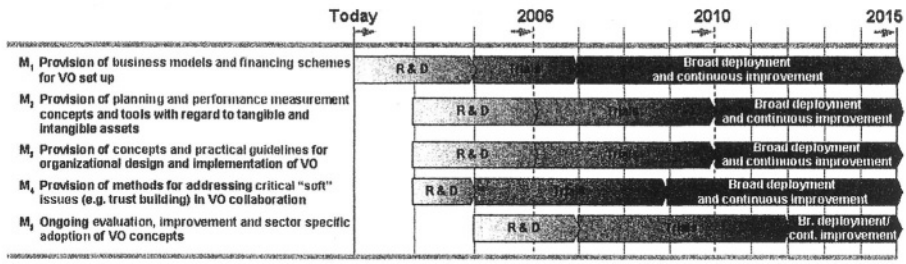

Today
2006
2010
2015
M1 Provision of business models and financing schemes for VO set up
M2 Provision of planning and performance measurement concepts and tools with regard to tangible and intangible assets
M3 Provision of concepts and practical guidelines for organizational design and implementation of VO
M4 Provision of methods for addressing critical "soft" issues (e.g. trust building) in VO collaboration
M5 Ongoing evaluation, improvement and sector specific adoption of VO concepts
R&D
Broad deployment and continuous improvement
Br. deployment/ cont. improvement

Figure 7 – Actions for the VO management focus area

Suggested distribution of efforts:

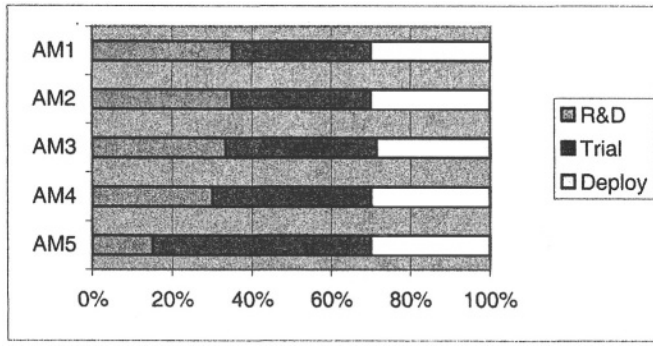


Figure 8 – Distribution of efforts for the VO management focus area

3.3 Support services focus

The Support Services Focus Area addresses the generic support mechanisms, which are needed as enablers creating an efficient ICT environment for the full life-cycle support of the Virtual Organizations. Support Services are the "vertical" IT applications (modules) built upon the horizontal ICT infrastructure for VOs. Their aim is to support all necessary functionally related to creation/running/dissolution of virtual organizations. They should be easy to use and generic enough to adapt to different applications and sectors. This may mean that they in many cases are parameterized. When a service module has received enough acceptances by VOs, it can in fact become a part of the ICT infrastructure itself. It seems however that such a possibility would be quite rare.

This focus area can be characterized by 5 key elements as shown in Fig. 9.

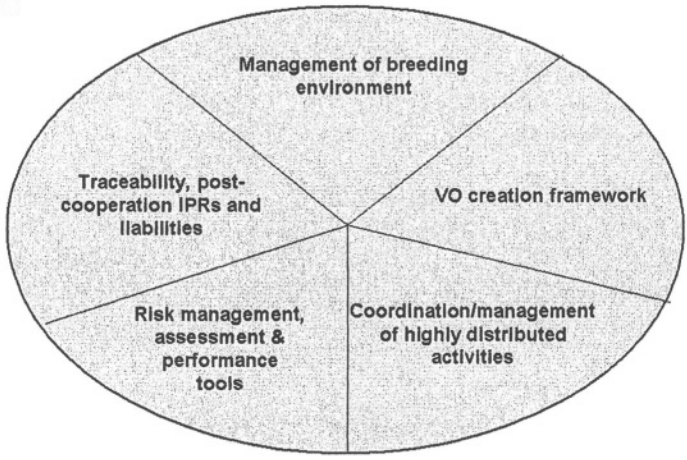

Management of breeding environment
Traceability, post-cooperation IPRs and liabilities
VO creation framework
Risk management, assessment & performance tools
Coordination/management of highly distributed activities

Figure 9 - Key elements of the support services focus area

Based on these elements, the following strategic research actions are proposed from the support services point of view, followed by the actions for the focus area and the distribution of efforts to reach its vision:

S1. Develop mechanisms and tools for management of breeding environment systems. The breeding environment has become an accepted approach in relation to Virtual Organizations. It is also realized that the breeding environment is dynamic and evolves with time responding to emerging needs. To cope with these needs, there have to be mechanisms and related tools to monitor and manage the breeding environment. This action includes activities to support the development and utilization of such tools:

- Role definitions for actors in breeding environment (e.g. network manager)
- Measures for performance of the breeding environment
- Methods for partner management in the breeding environment, like tools for trust management, qualification and disqualification procedures

- Understanding of relationship between actions and performance of the breeding environment
- Tools and platforms for collaboration in professional communities
- Development of modules for the management of the breeding environment. The management also includes identification of needed new support services
- Relevant guidelines for the use of the developed modules.

S2. Identify and develop generic services for VO life cycle support (e.g. distributed Business Process management, e-contracting, VO configuration, e-training). The Virtual Organization requires different types of support services depending of its life cycle phase. The services are provided and maintained by the breeding environment as a part of its management. The services should include:

- Services for the creation of the Virtual Organisation (Partner registers and search mechanisms, Contract preparation support including principles for profit and responsibility sharing, Support for set-up of collaboration platforms, etc)
- Services for the operation of the Virtual Organisation (Performance measures, Management methods and procedures, Training, etc.)
- Services for disclosure of Virtual Organisations and post-VO activities (Distribution of revenues and benefits, Experiences and learning, Management of post-VO responsibilities, etc).

S3. Develop mechanisms and tools for traceability, knowledge exchange and inter-VO transactions (supporting products and services life cycle). The concern for the full life cycle of products is increasing. Especially, in relation to capital intensive products (manufacturing sites, infrastructures, etc) this trend is strong. This means that during the life cycle of such products several Virtual Organizations are involved in specific activities related to their creation, operation and dissolution. Some of the VOs may exist simultaneously, but many have life cycles appearing during separate phases of the product life cycle. This action intends to develop mechanisms for exchange and traceability knowledge, which may be relevant for several VOs at different times. It includes:

- Methods and tools for information an knowledge management over the full product lifecycle
- Tools for collaborative design & engineering
- Relationships between product functionality and physical product
- Mechanisms for feedback of operational knowledge to design and engineering phases.

S4. Elaborate mechanisms and tools to support VO's "inheritance" management. The "results" of the VO operation (generated knowledge, devised practices, developed products and processes, etc.) need to be handled after the VO dissolves. This "inheritance" relates to each VO partner and to further VOs that will continue the "processes" started by the VO being dissolved. It includes:

- Governing principles for joint knowledge management and ownership
- VO dissolution management, including procedure handbook, guidelines, legal contracts

- Collection and management of experiences, actions, etc. from the lifecycle of VO: Practices, Partners performances, Performance indicators.
- Collection and management of outputs and results created by the VO: Joint knowledge, IP ownership, Liabilities and enforcement mechanisms.

S5. Elaborate business models for support service systems and tools. Many support functions have been developed for specific applications. The development of generic support functions requires an understanding of the needs and the related business. This action aims at defining an approach for the support function business. It includes:

- Definition of different stakeholders and their needs
- Evaluation of approach to generic support systems (e.g. relevant parameterisation) and their business opportunities
- Suggestions (with guidelines) for different approaches to create business of the support services.

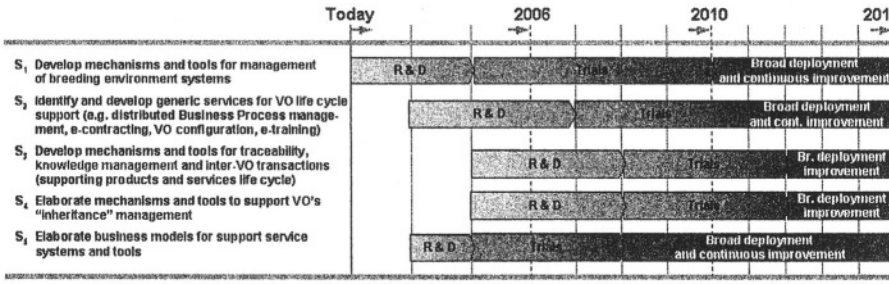

Today
2006
2010
2015
S1 Develop mechanisms and tools for management of breeding environment systems
S2 Identify and develop generic services for VO life cycle support (e.g. distributed Business Process management, e-contracting, VO configuration, e-training)
S3 Develop mechanisms and tools for traceability, knowledge management and inter-VO transactions (supporting products and services life cycle)
S4 Elaborate mechanisms and tools to support VO's "inheritance" management
S5 Elaborate business models for support service systems and tools
R&D
Trials
Broad deployment and continuous improvement
Broad deployment and cont. improvement
Br. deployment improvement
Br. deployment improvement
Broad deployment and continuous improvement

Figure 10 – Actions for the support services focus area

Suggested distribution of efforts:

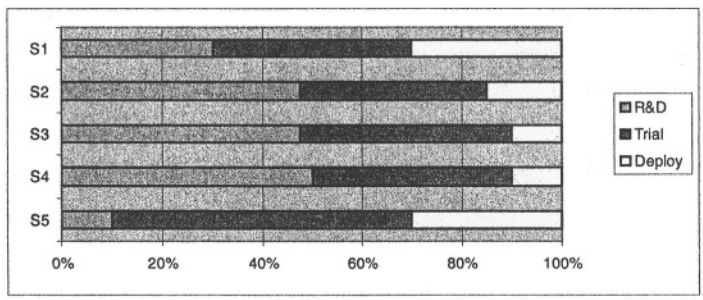


Figure 11 – Distribution of efforts for the support services focus area

3.4 ICT infrastructure focus

The ICT infrastructure focus area addresses the necessity for a "horizontal software development platform" to support the base information handling and interaction/communication requirements for cooperation within virtual organization. A main goal for the ICT infrastructure development is to serve as the base for a wide range of "vertical" support services and applications that will be implemented for

virtual organizations. Therefore on one hand, the "reference architecture" for ICT infrastructure must be both technology-independent and platform-independent. On the other hand, it must benefit from advances in emerging ICT tools and technologies, and as much as possible apply them as its building blocks.

This area can be characterized by 6 key elements as shown in Fig. 12.

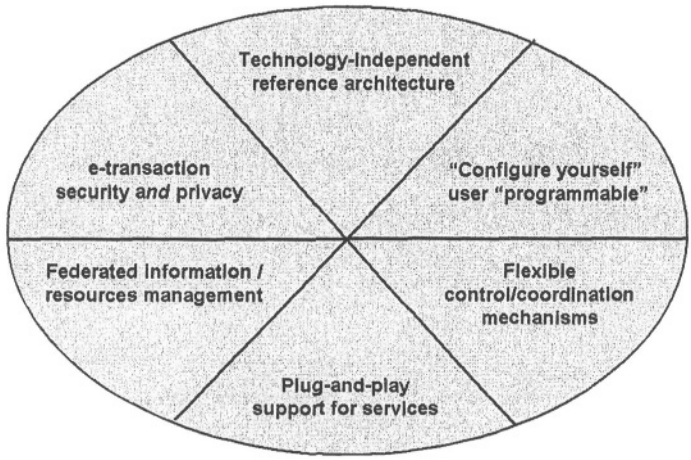


Figure 12 - Key elements of the ICT infrastructure focus area

Based on these elements, the following set represents the main specific actions proposed for the development of the ICT infrastructure, followed by the actions for the focus area and the distribution of efforts to reach its vision:

I1. ***Establish the principles of reference architecture, interoperability, and security.*** This action provides guidelines, principles, methodologies, reference architectures for the ICT based interaction and secure interoperation among the organization involved in the VO, and thus supports organizations with making their applications and legacy ICT infrastructures suitable for networked organizations. It shall include:

- Framework for an ICT technology-independent reference architecture for collaborative networks
- Interoperability principles foundation; migration and integration of legacy from past R&D on VO
- Approaches for enterprise applications integration
- Semantic mediation over formats, protocols, and models.

I2. ***Establish foundation for systems evolution, software technology migration and systems integration.*** The horizontal ICT infrastructure needs to be based on and standardize a common software environment, for its development. As the components of the software environment are likely to change / evolve, software migration becomes a critical issue. This action addresses the main steps in defining this environment and includes:

- Standardization and definition of the methodology for maintenance and evolution of the base ICT software components.
- Establishing rules for ICT software migration and compatibility of releases.

- Definition of a framework and common strategy for integration of the vertical support services with the ICT infrastructure.

I3. Develop generic, user-friendly (transparent !), and low-cost (affordable!) ICT infrastructure. Networked organizations need to be able to quickly define and set-up relations with other organizations, which requires a plug-&-play-&-do-business infrastructure. Also considering the required impact on the SMEs, the base ICT infrastructure must be completely affordable for SMEs, if not free of charge. This action includes:

- Elaboration of inter-enterprise plug-&-play concept
- Configurable, multi-level security architecture and mechanisms
- Exploitation of emerging technologies (including technology watching) – MAS, GRID, semantic web, …
- Federated information and resources management support
- Web multi-channel accessibility
- Infrastructure and quality of service monitoring facilities
- Technologies for managing relationships within VOs

I4. Develop a "do it yourself" framework to assist the development of VO support services. A main goal for the separation between the horizontal and vertical software development for VOs, is for the horizontal infrastructure to provide a generic, and easy to use / adapt "base", on top of which specialized "support services" can be developed and integrated. As such, any necessary integration with (and adaptation of) the base ICT infrastructure must be facilitated, to be performed by the vertical service developers themselves. The action includes:

- Principles for "user-programmable" infrastructure
- Context-adapting infrastructure; semantically-informed, self-organizing infrastructure
- Expand the open-source inspired "scripting" approach
- Training program.

I5. Define a business model for developers, suppliers, and buyers of the ICT infrastructure developments and support software. To be commercially available and maintained, similar to any other software developments, a business model must exist, also regulating the rights, liabilities, benefits, etc. for the development of the ICT base infrastructure for VOs, considering all involved parties. This action shall include:

- Identification and characterization of stake holders in the "VO infrastructure" business
- Elaboration of suitable business models
- Low cost deployment methods
- Assessment of models and methods.

I6. Elaborate approaches to handle reliability and responsibility, when using multi-supplier building blocks. The ICT base infrastructure for VOs will develop, as much as possible, on top of the common and standard tools, using them as its building blocks. Using these multi-supplier building blocks, requires clear identification of each supplier's responsibilities and liabilities. This action includes:

- Definition of a model for division of responsibility/liability among different suppliers.

- Linking the responsibility/liability model with a business model for using other suppliers' software.
- Reaching agreement with other suppliers on the defined model.

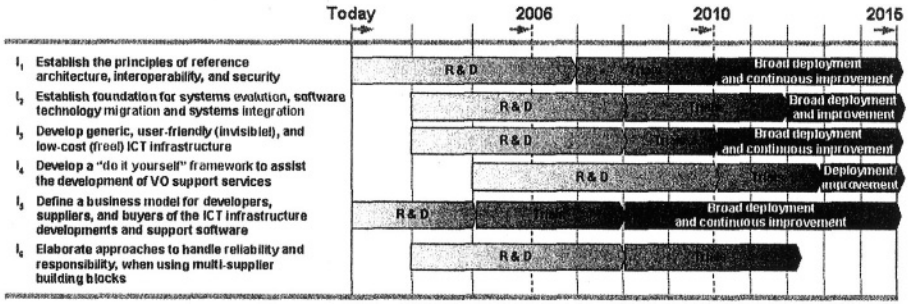

Today
2006
2010
2015
I1 Establish the principles of reference architecture, interoperability, and security
I2 Establish foundation for systems evolution, software technology migration and systems integration
I3 Develop generic, user-friendly (invisible!), and low-cost (free!) ICT infrastructure
I4 Develop a "do it yourself" framework to assist the development of VO support services
I5 Define a business model for developers, suppliers, and buyers of the ICT infrastructure developments and support software
I6 Elaborate approaches to handle reliability and responsibility, when using multi-supplier building blocks
R&D
Broad deployment and continuous improvement
Broad deployment and improvement
Broad deployment and continuous improvement
Deployment/ improvement
Broad deployment and continuous improvement

Figure 13 – Actions for the ICT infrastructure focus area

Suggested distribution of efforts:

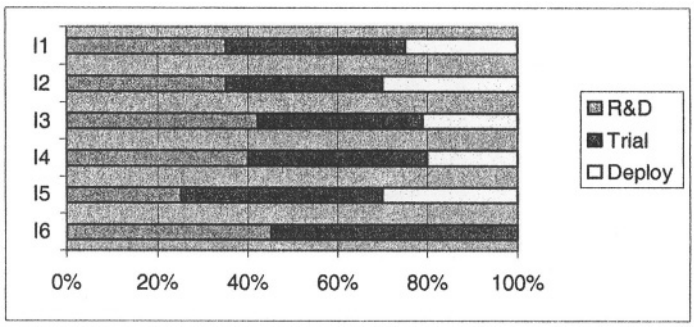


Figure 14 – Distribution of efforts for the ICT infrastructure focus area

3.5 Formal models and theories focus

A sound theoretical foundation is a key requirement for the progress in the area of Virtual Organizations. In fact, one of the main weaknesses in the area of collaborative, networked organizations is the lack of appropriate theories, consistent paradigms and formal modeling tools. This situation constitutes a major obstacle for both the interaction among experts from multiple disciplines that are involved in the VO research as well as for the recognition of virtual organizations as a scientific discipline. There is a need to design several rigorous models to properly define VOs from the point of view of different disciplines. There is also a need for these reference models' integration /interoperation and for the definition of metrics and certification criteria associated to these reference models. Nevertheless, some theories and paradigms defined elsewhere have been suggested by several research groups as promising tools to help understand and characterize emerging collaborative organizational forms and constitute the starting basis in this focus area.

This area can be characterized by 6 key elements as shown in Fig. 15.

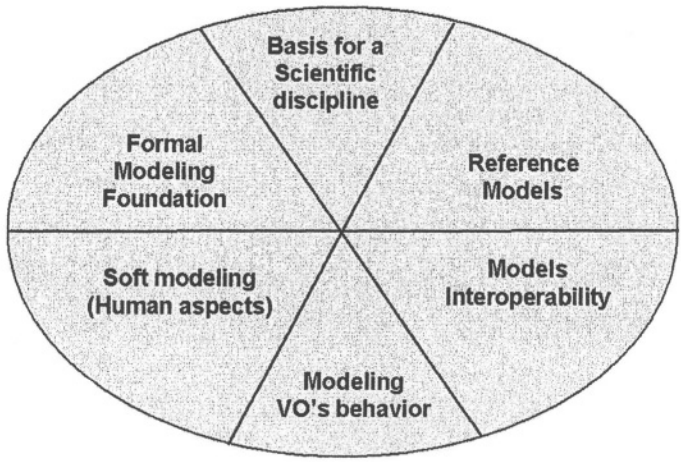


Figure 15 - Key elements of the formal models and theories focus area

Based on these elements, the following strategic research actions are proposed from the formal models and theories point of view, followed by the actions for the focus area and the distribution of efforts to reach its vision:

F1. Establish a formal theoretical foundation and methodology for modeling dynamic collaborative networks. This action shall include:
- Hands-on assessment of promising modeling approaches: formal languages, graph theory, multi-agent models, game theory, modal logics, etc.
- Identification and characterization of the necessary modeling *purposes*
- Establishment of a map between needed modeling purposes and promising modeling tools ("shopping list")
- Formalization of existing empirical knowledge based on selected representative cases
- Promotion of education and increasing awareness for the need of a theoretical foundation.

F2. Define basic formal reference models (including ontologies) for collaborative networks at general and focused-area levels. This action shall include:
- Consolidation of results and their abstraction in terms of a general reference model (semi-formal and easily understandable by humans)
- Development of an engineering methodology for application of the reference model
- Advanced reference models and guidelines for development of advanced collaborative, networked organizations.

F3. Elaborate soft modeling approaches and soft models to both handle incomplete / imprecise knowledge and capture the social/human aspects in collaborative networks. Action including:
- Combination of soft engineering models and social theories
- Combination of game theory and social networks
- Development of soft reasoning models and decision-making support
- Development of graphical visualization and simulation tools
- Understanding of leadership, actors' roles, and social bodies roles.

F4. Devise mechanisms for evolution and maintenance of reference models for collaborative networks. This action shall include:
- Identification of actors responsible for models maintenance
- Elaboration of mechanisms to support models evolution.

F5. Elaborate approaches for models interoperability, supporting multiple modeling perspectives (e.g. structure, behavior) at generic and focused area levels. Action involving:
- Characterization of multi-level modeling perspectives and their needs
- Devising approaches for models interoperability and integration, starting with bilateral work for each two pairs of inter-related modeling approaches (to digest the commonalities and identify the necessary extensions).

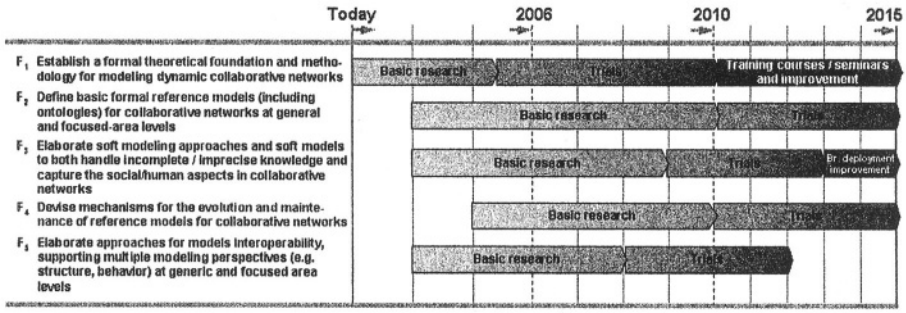

Today
2006
2010
2015
F1 Establish a formal theoretical foundation and methodology for modeling dynamic collaborative networks
F2 Define basic formal reference models (including ontologies) for collaborative networks at general and focused-area levels
F3 Elaborate soft modeling approaches and soft models to both handle incomplete / imprecise knowledge and capture the social/human aspects in collaborative networks
F4 Devise mechanisms for the evolution and maintenance of reference models for collaborative networks
F5 Elaborate approaches for models interoperability, supporting multiple modeling perspectives (e.g. structure, behavior) at generic and focused area levels
Basic research
Trials
Training courses / seminars and improvement
Basic research
Basic research
Trials
Basic research
Trials

Figure 16 – Actions for the formal models and theories focus area

Suggested distribution of efforts:

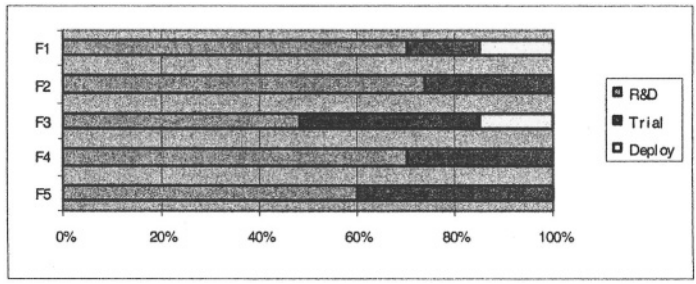


Figure 17 – Distribution of efforts for the formal models and theories focus area

4. THE ROADMAP - OVERVIEW

When defining the final version of the roadmap three phases of activities are considered: (1) R&D, (2) Trials, and (3) Broad deployment. Fig. 18 shows the integrated roadmap, including all the five focus areas.

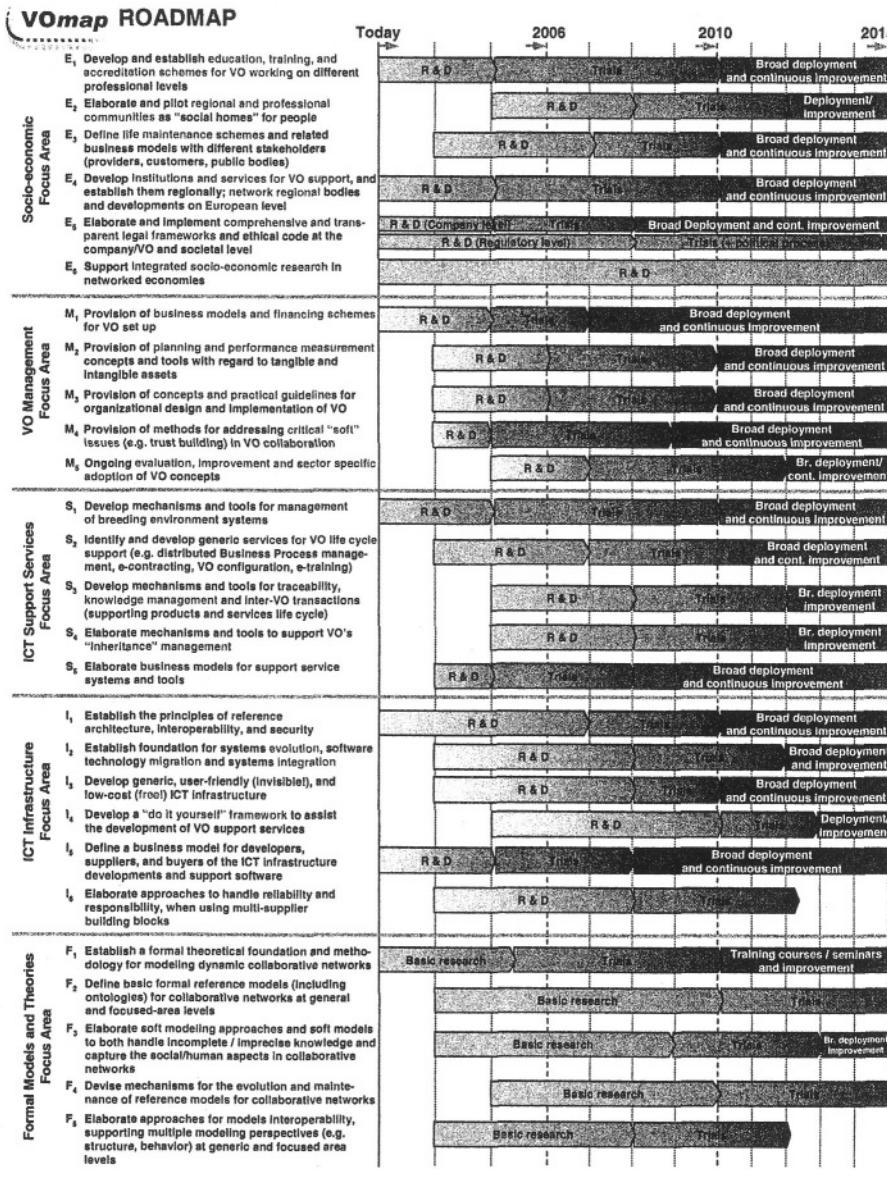

VOmap ROADMAP
Today
2006
2010
2015
Socio-economic Focus Area
E1 Develop and establish education, training, and accreditation schemes for VO working on different professional levels
E2 Elaborate and pilot regional and professional communities as "social homes" for people
E3 Define life maintenance schemes and related business models with different stakeholders (providers, customers, public bodies)
E4 Develop institutions and services for VO support, and establish them regionally; network regional bodies and developments on European level
E5 Elaborate and implement comprehensive and transparent legal frameworks and ethical code at the company/VO and societal level
E6 Support integrated socio-economic research in networked economies
VO Management Focus Area
M1 Provision of business models and financing schemes for VO set up
M2 Provision of planning and performance measurement concepts and tools with regard to tangible and intangible assets
M3 Provision of concepts and practical guidelines for organizational design and implementation of VO
M4 Provision of methods for addressing critical "soft" issues (e.g. trust building) in VO collaboration
M5 Ongoing evaluation, improvement and sector specific adoption of VO concepts
ICT Support Services Focus Area
S1 Develop mechanisms and tools for management of breeding environment systems
S2 Identify and develop generic services for VO life cycle support (e.g. distributed Business Process management, e-contracting, VO configuration, e-training)
S3 Develop mechanisms and tools for traceability, knowledge management and inter-VO transactions (supporting products and services life cycle)
S4 Elaborate mechanisms and tools to support VO's "inheritance" management
S5 Elaborate business models for support service systems and tools
ICT Infrastructure Focus Area
I1 Establish the principles of reference architecture, interoperability, and security
I2 Establish foundation for systems evolution, software technology migration and systems integration
I3 Develop generic, user-friendly (invisible), and low-cost (free) ICT infrastructure
I4 Develop a "do it yourself" framework to assist the development of VO support services
I5 Define a business model for developers, suppliers, and buyers of the ICT infrastructure developments and support software
I6 Elaborate approaches to handle reliability and responsibility, when using multi-supplier building blocks
Formal Models and Theories Focus Area
F1 Establish a formal theoretical foundation and methodology for modeling dynamic collaborative networks
F2 Define basic formal reference models (including ontologies) for collaborative networks at general and focused-area levels
F3 Elaborate soft modeling approaches and soft models to both handle incomplete / imprecise knowledge and capture the social/human aspects in collaborative networks
F4 Devise mechanisms for the evolution and maintenance of reference models for collaborative networks
F5 Elaborate approaches for models interoperability, supporting multiple modeling perspectives (e.g. structure, behavior) at generic and focused area levels
R&D
Trials
Broad deployment and continuous improvement
Deployment/ improvement
Broad Deployment and cont. improvement
R&D (Regulatory level)
Br. deployment/ cont. improvement
Broad deployment and cont. improvement
Br. deployment improvement
Broad deployment and improvement
Training courses / seminars and improvement
Basic research
Br. deployment improvement

Figure 18 – VOmap roadmap

It shall be noted that the three mentioned phases do not happen in a strict sequential

order, but they rather partially overlap (Fig. 19).

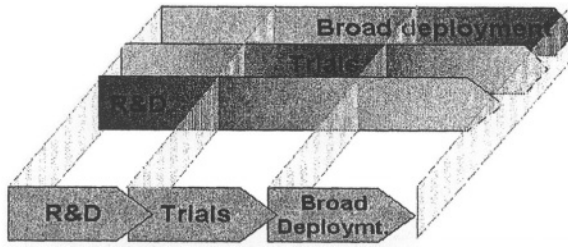


Figure 19 – Implementation phases and their "intensity" periods

Therefore, an R&D block in Fig. 18 shall be interpreted as this being a phase were the main emphasis is on R&D although some trials and even broad deployment of partial results might start in parallel. Also, the interdependencies among actions are not shown in Figure 18.

Figure 20 shows the main inter-dependencies among the proposed actions. A crossed cell means that the action indicated in the corresponding row depends on some information to be provided by the action indicated in the corresponding column.

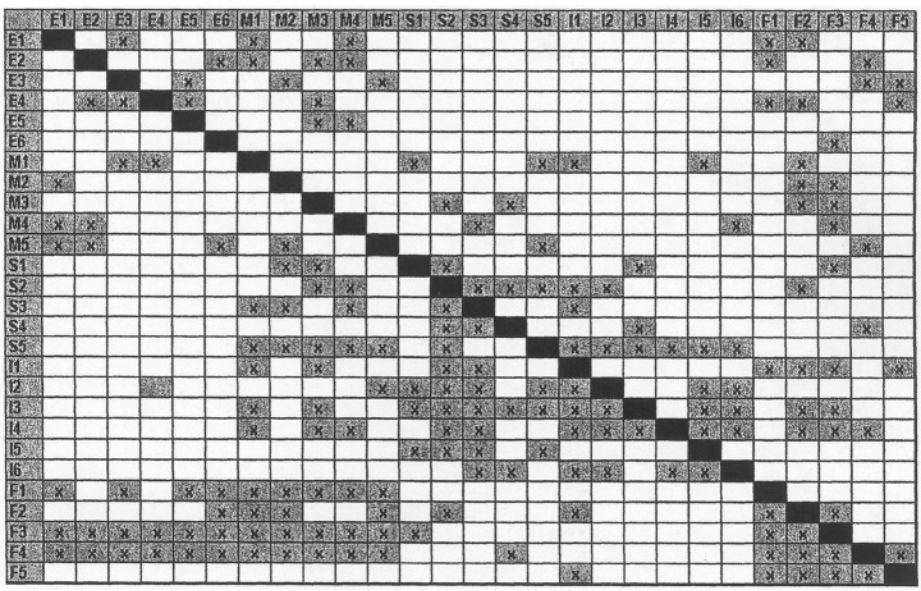


Figure 20 – Main inter-dependencies among actions

As illustrated, there are many inter-dependencies among actions in different focus areas, which also confirm that the progress on advanced virtual organizations needs a holistic approach involving several disciplines, and cannot be successful as fragmented research.

5. ROADMAP EVOLUTION

Roadmapping is not a one-step activity and a roadmap result, such as the VOmap roadmap, should not be seen as a static plan. The environment changes constantly, e.g. the socio-economic conditions, trends, and technological reality considered during the roadmapping process are in a continuous evolution stage. Furthermore, when the time frame considered is long, e.g. 5 or 10 years ahead, it is quite difficult to forecast what the conditions will be at that time. Therefore, during the roadmap implementation, it is necessary to proceed with the periodic revisions of the roadmapping steps, namely the baseline, vision, and proposed actions, so that the roadmap plan can be tuned with the evolving conditions.

It is therefore recommended that any research project that might be launched to implement parts of the VOmap roadmap should itself include, as a continuous horizontal activity, a roadmap revision and update task.

6. CONCLUSIONS

Collaborative networks in general, and the virtual organizations in particular, provide a basis for competitiveness, world-excellence, and agility in turbulent market conditions. Reinforcing the effectiveness of collaborative networks and creating the necessary conditions for making them an endogenous reality in environments, such as the European industrial landscape mostly based on SMEs, is a key challenge.

During the last decade, and in parallel with the development and spreading of Internet technologies, traditional collaboration networks have found new leveraging tools, and the new collaborative business forms have emerged. In terms of research, there has been significant activity during the last decade especially in Europe in the area of Virtual Organisations. However, these initiatives correspond to *fragmented* research and in most cases, due to the funding criteria, target very short-term objectives, focused on solving specific and limited problem, and are too biased by "fashionable" short-life technologies. It is therefore necessary to start a new phase of research and development on virtual organizations, characterized by a holistic approach that takes into account the necessary interactions among multiple disciplines involved in the collaborative networked organizations, and focused on the development of sound principles, models, and theories.

Finally, it shall be noted that the proposed roadmap of the VOmap project is not a detailed plan for a specific research project but rather a generic plan out of which a number of research projects can be derived.

Acknowledgements. The authors thank the contribution of their VOmap partners – Gunter Konzilia, Bernhard Koelmel, Antonio Abreu - and all participants in the VOmap workshops for their contribution to the design of the VOmap roadmap.

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ANNEXES

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METHOD OF WORK IN THINKcreative PROJECT

The VO paradigm and the new emerging collaborative (networked) organizational forms involve a large number of disciplines, whose strong collaboration and joint developments is a necessity for proper understanding and providing support tools, mechanisms, and methodologies, to address different aspects of the collaborative networks.

However, forecasting the future in the context of fast evolving environments is a hard if not an impossible task. Nevertheless, by acquiring contributions from a large number of experts and industry visionaries, identification of the emerging trends and needs can be facilitated.

For this purpose a multi-activity program was defined in the THINKcreative project, as illustrated at the high level by the IDEF0 diagram in Fig. 1.

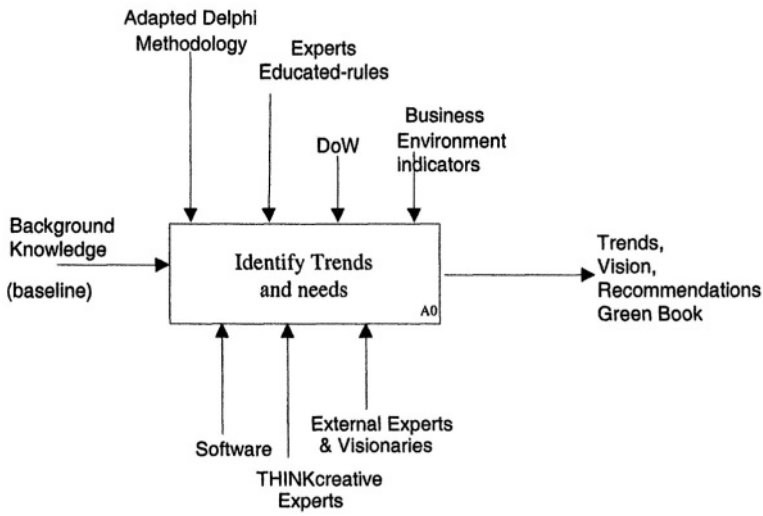

Figure 1 – THINKceative activity context at the high level

Furthermore, as the key mechanisms for this high level plan, three types of activities were planned consisting of: (A1) elaboration of a Delphi survey, (A2) organization of a series of regional workshops, and (A3) organization of a number of focused workshops devoted to specific issues. Finally, the step (A4) an integration of the results of these three lines of activities and provision of the **research recommendations** completes the plan of work in THINKcreative (Fig.2).

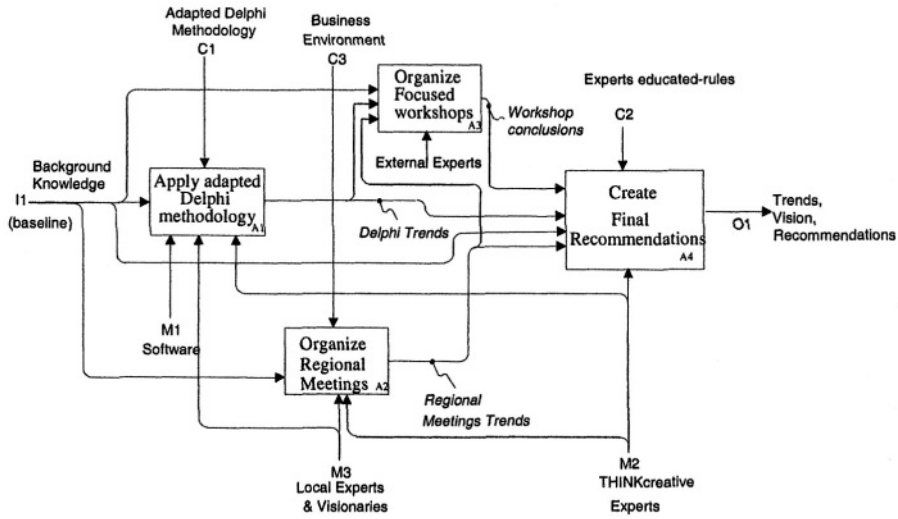

Figure 2 – Main activities towards preparation of a research agenda

In order to perform the Delphi survey a variation of the Delphi method was adopted (Fig. 3).

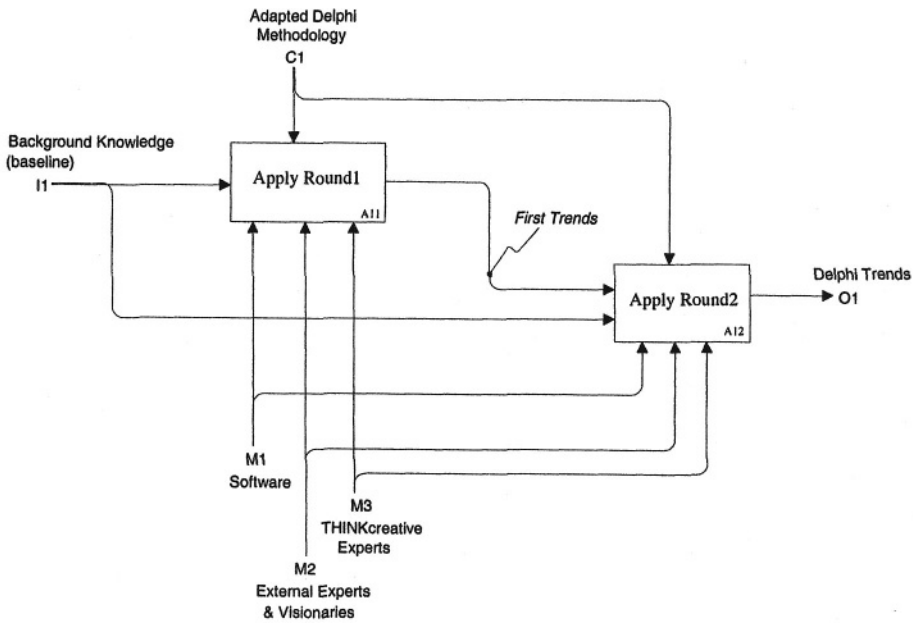

Figure 3 – Adaptation of the Delphi methodology

In the first step, through an internal brainstorming session, involving the THINKcreative consortium expertise from multiple disciplines, a preliminary set of major trends was identified. Based on these trends a Delphi questionnaire was elaborated and an effort to collect a large number of answers was put in place. Finally an analysis of the results led to a synthesis list of observations and recommendations.

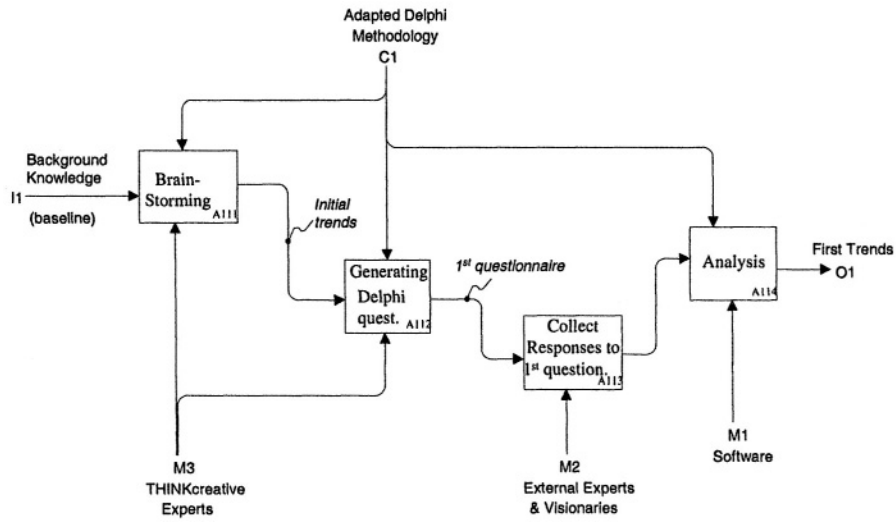

Figure 4 – First round of the adapted Delphi methodology

At this stage, the synthesis of Delphi findings and a set of recommendations were published as an interim report, and then a 2nd phase of feedback collection took place.

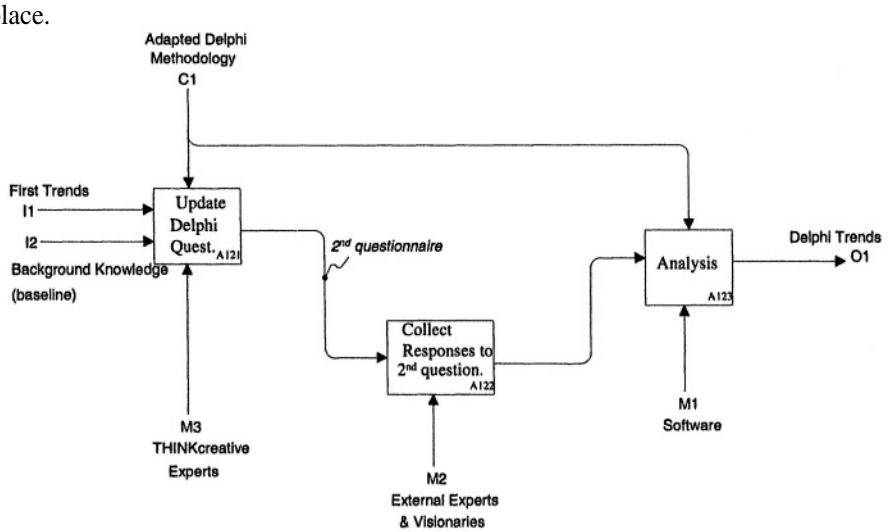

Figure 5 – Second round of the adapted Delphi methodology

In the second step, the regional workshops were designed to facilitate the involvement of a large number of *industry visionaries* and other experts from different regions. Also, in order to facilitate the integration of results, a common structure and a common set of *guiding questions* were defined for all workshops (Fig. 6).

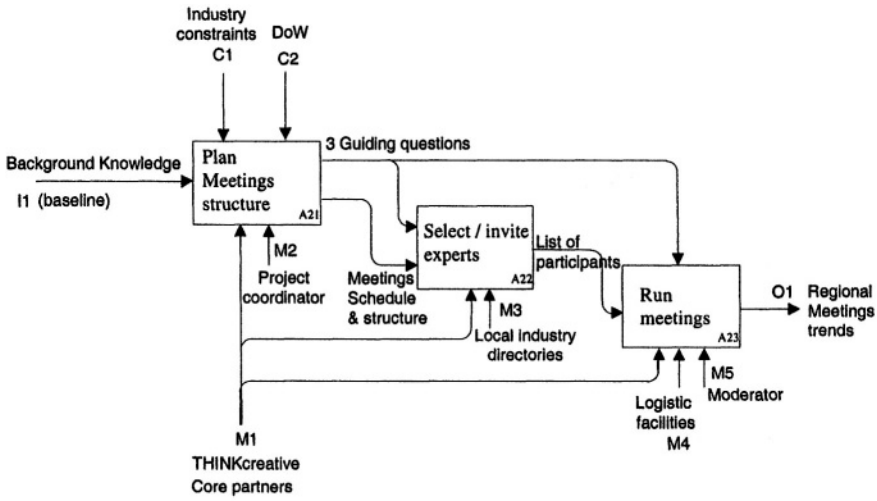

Figure 6 – Organization of regional workshops

While the regional workshops were intended to capture the opinions (*vision*) of a large number of active local experts from different regions, the focused workshops were also organized, devoted to the discussion of specific topics (Fig. 7).

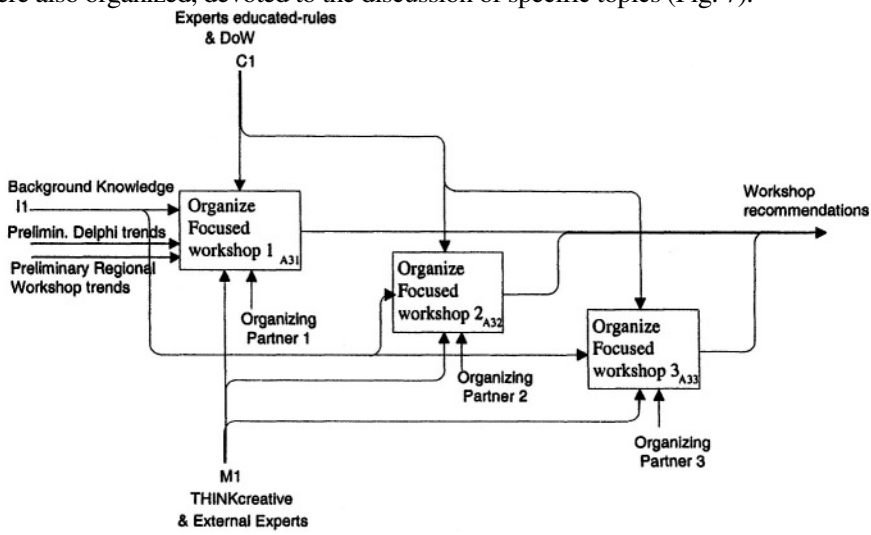

Figure 7 – Organization of focused workshops

In the third step, in relation to each topic a number of external experts were invited to participate in focused workshops, giving a brief panorama of their field of expertise and how their topic could contribute to CNOs.

In the fourth and final step, the integration and synthesis of all the collected contributions and recommendations were achieved, also performing some gap analysis (Fig. 8).

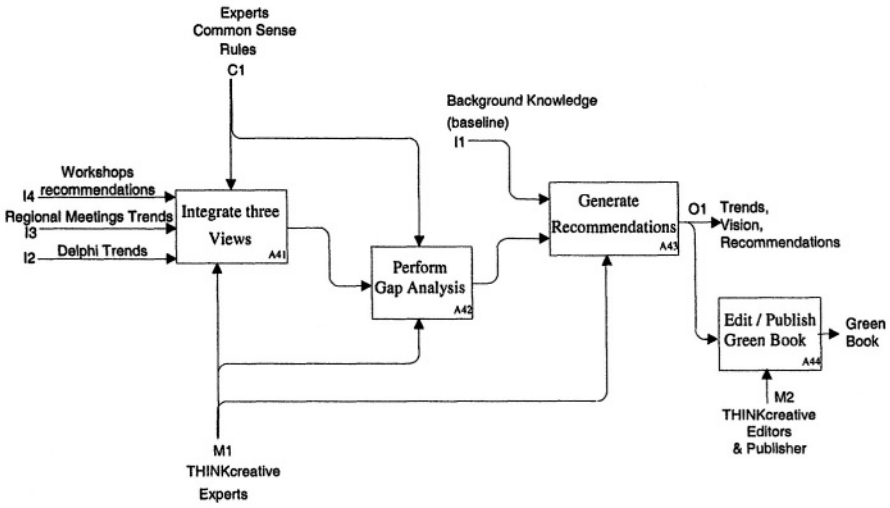

Figure 8 – Integration and synthesis of recommendations

The main planned results of the THINKcreative are presented in this book where a collection and synthesis of the various findings and recommendations is included. Additionally, the project's (interim) reports and several earlier publications also present the main trends and vision for CNOs in the future, and the recommendations for research actions.

SUBJECT INDEX

ACL, 195
Added value, 148
Agent-based simulation, 248
Agent technology, 193, 245

Best practice, 15
BPL4WS, 215
Broker, 28, 181
Business ethics, 155
Business processes, 36

Causal dynamics, 117
Challenges for VO, 81
  Organizational and management, 82
  Technical / technological, 84
  Legal, 86
  Socio-ethical, 87
  Regional and global, 88
  For the individual, 128
Collaborative knowledge networks, 139
Collaborative networked organizations - CNO, 3, 10, 103, 162, 237
Collaborative networks, 3, 98, 140, 229, 253
Communities of practice, 144
Complexity, complexity theory 231, 241
Coordination, 176, 177, 293, 299
Creative economy, 123

Delphi survey, 69
Driving forces, 34, 70
Dynamic CN, 43
Dynamic virtual organization, 9

ebXML, 207
Ecosystem, 140
Emergence and emerging behavior, 132, 159, 229
e-Science, 54, 187
Ethical and moral issues, 87, 153
Extended enterprise, 9, 114

Federated information management, 176, 179, 293
FIPA, 200
Formal modeling, 237, 255, 306
Formal theories, 237, 240, 306

Game theory, 240
Gap analysis, 280
Global networked firm, 32
Graph theory, 240
GRID, 108, 209

Holistic approaches, 233
Holons, 195
Hyper-norms, 169

ICT infrastructures, 107, 175, 303
  Horizontal infrastructure, 178, 303
  Layer-based, 178
  Agent-based, 179
  Service federation, 179
Inhibitors and challenges of VO, 23
Interoperability, 177, 198, 200, 241

J2EE, 216

Knowledge workers, 106

Linux community, 136

Meta-agents, 203
Meta-ethics, 157
Meta-modeling, 115
Metaphors, 240
Mobile agents, 194
Mobile computing, 218
Multi-agent systems, 194, 231, 245, 249

.NET, 216
New worker, 46, 62
Normative models, 266

Online training, 60
Ontologies, 197, 202, 241, 267
Organizational behavior, 126

Performance measurement, 147
Pervasive computing, 221
Potentials of VO, 21
Professional virtual community, 9, 31, 185

Roadmap, 275, 294, 309
Roadmapping, 275
Regional challenges
  Europe, 77
  Japan, 91
  Australia, 97
  Brazil, 103
  USA, 113
Regional clusters, 28, 91, 92
Remote supervision, 187
RosettaNet, 203

SAML, 214
Self-organizing systems, 232, 294
Semiotics, 240, 261, 262
Shop-floor re-engineering, 189
Small worlds, 232
SOAP, 213
Social contract, 164
Social models, 253
Socio-organizational challenges, 123, 144
Softness and soft modeling, 118, 253
Strategic management, 131
Strategy formation, 134
Success factors, 21, 142

Time Bank, 48
Types of VO, 79

UDDI, 213

Virtual enterprise, 8, 18, 245, 248
Virtual institutes, 58
Virtual laboratory, 187
Virtual organization - VO, 9, 15, 78, 104, 289
Virtual Organization cases
  Building industry, 18
  Manufacturing industry, 19
  Trade organizations, 20
  Rescue actions, 44
  Elderly care, 50
  Women NGO, 52
  e-Science, 54
  Gaming, 56
Virtual Private Networks, 217
Virtuelle Fabrik, 16
Visioning, 278, 289
VO breeding environment, 9, 28, 92, 104, 180
VO creation, 180
VO evolution and dissolution, 184
VO management, 297
VO operation, 183
VO support services, 301

Web services, 210
WSIL, 213

AUTHOR INDEX

Abreu, A., 69
Afsarmanesh, H., 41, 69, 77, 175, 207, 229, 237, 275, 289
Alexakis, S., 15

Banahan, E., 41, 123
Barata, J., 41

Camarinha-Matos, L.M., 41, 69, 77, 175, 207, 229, 237, 275, 289

Evans, S., 139, 147

Filipe, J., 261

Goranson, H. T., 113

Hawkins, S., 153
Heep, T., 15

Joode, R.W., 131

Kaihara, T., 91
Katzy, B., 27
Kemp, K., 131
Kölmel, B., 15

Loeh, H., 27, 289

Marik, V., 77, 193, 245
Mo, J., 97

Nemes, L., 97

Ollus, M., 289

Pěchouček, M., 193, 245
Pereira-Klen, A. A., 103
Playfoot, J., 41, 123

Rabelo, R.J., 103
Roth, N., 139, 147

Soares, A. L., 253
Sousa, J. P., 41, 253
Sturm, F., 41, 131, 147, 289

Tschammer, V., 41, 207

Zhang, C., 27